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SAMPLING CONVERTER PLUG-IN UNIT

TYPE 701

INSTRUMENTS & MEASUREMENTS
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ANALAB

BENRUS
TECHNICAL PRODUCTS DIVISION

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INSTRUCTION MANUAL

SAMPLING CONVERTER PLUG-IN UNIT

TYPE 701

BENRUS TECHNICAL PRODUCTS DIVISION

30 Cherry Avenue
Waterbury, Connecticut, U. S. A.
Area Code: 201, 756-4621

06-08-67
00031

ADDENDUM

The Type 701 Sampling Plug-in is superseded by the Type 701-1. The Type 701-1 incorporates the memory circuit which is capable of holding the sampled signal for at least one second, thus making it possible to sample and reconstruct waveforms with repetition rates as low as one pulse per second.

In addition, the Type 701-1 has a Video Trigger Control, which assures synchronization of signals whose resolution rates occur between approximately 10 Mc and 100 Mc. With the addition of this control, Analab Sampling Oscilloscopes now lock stably at any repetition rates from 1 pps to several thousand Mc.

There is no sharp line of demarcation in frequency at which the video trigger circuit should be used. For best operation the following is advised:

1. For normal use, up to around 10 Mc and above 100 Mc, pull the video trigger switch to its outer position. This switch is located directly above the external trigger input. If stable synchronization is obtained, leave the switch in its outer position.
2. If signals are close to the 10 to 100 Mc band, try pushing in the video trigger switch for better synchronization.
3. Use the position of the video trigger switch which gives best synchronization for any particular signal. A different setting of the Level Control will probably be required for the two positions of the video trigger switch.
4. The video trigger circuit operates for both internal and external synchronization.

10/26/66

DRAWING NUMBER

SHEET OF

UNLESS OTHERWISE SPECIFIED
FRACTIONS: ±1/64
2-PLACE DECIMALS: ±.01
3-PLACE DECIMALS: ±.005
ANGLES ±1° 0' 0"
INSIDE RADII: 1/32 MAX R
REMOVE ALL BURRS
BREAK ALL SHARP EDGES
DO NOT SCALE THIS DRAWING

TITLE VHF TRIGGER CKT

DRAWING NUMBER 907-013-003

DR.
CK.
APPR.

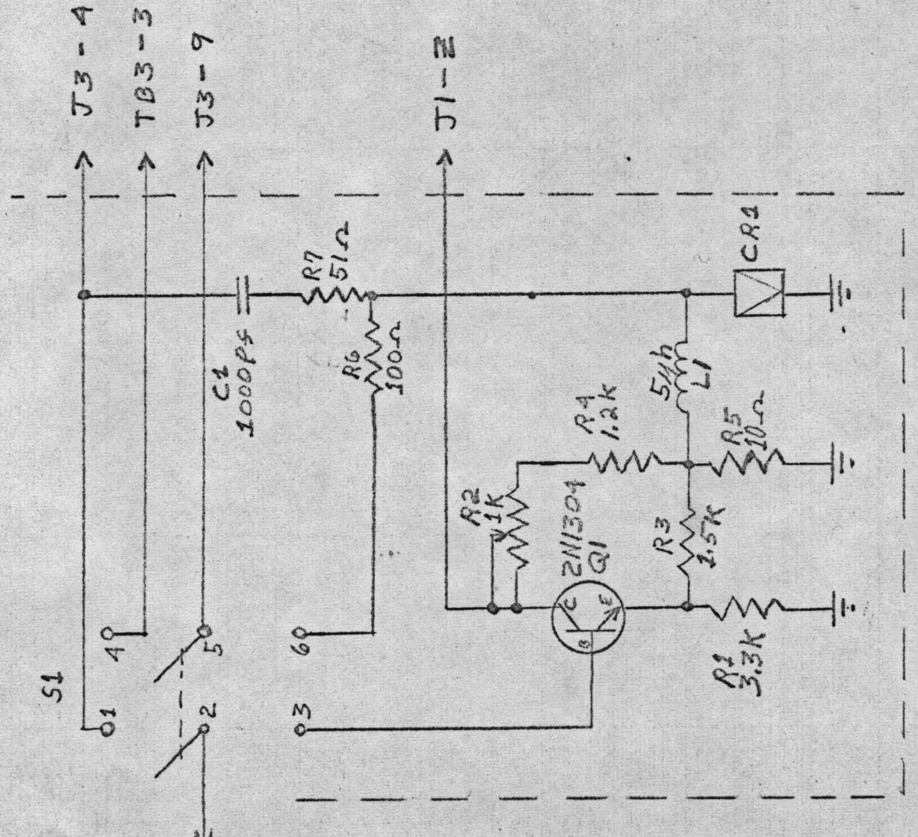
SCALE
SH. OF

MATERIAL:

FINISH:

BENRUS WATCH CO., INC.
WATERBURY MFG. DIV.
30 CHERRY AVENUE
WATERBURY, CONN.

REVISION
SYM ECN



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SECTION I.

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Analab Type 701 is a sampling converter plug-in designed to extend the capabilities of the Analab 1100 series oscilloscope and 1220 series storage scope frames for viewing and measuring pulses with sub-nanosecond risetimes and gigacycle trigger rates, at amplitudes ranging from a few millivolts to 200 volts.

The 701 sampling plug-in has dual channel vertical inputs, internal trigger takeoff capabilities and a variable internal sweep delay to allow the second or later pulses in a high frequency pulse train to be examined closely.

When used with the Analab type 1220 storage frame, the 701 allows direct comparison of nanosecond pulses obtained at widely different times; e.g., even hours later after a circuit component has been changed.

The 701 can also drive X-Y plotters to make a permanent record of voltage vs. time or Lissajous patterns.

A complementing line of low capacity resistive probes, high impedance probes and other nanosecond instruments is available to work with the 701. Consult your nearest representative for up-to-date information.

1.2 SPECIFICATIONS

SPECIFICATIONS

(TYPE 701 PLUG-IN WITH TYPE 1120 MAIN-FRAME)

DUAL CHANNEL A AND B VERTICAL AMPLIFIERS

RISETIME:	Less than 500 picoseconds (10% to 90%).
SENSITIVITY:	2 millivolts/cm to 200 millivolts/cm in 7 calibrated ranges; attenuator accuracy ±3%; variable uncalibrated gain control increases sensitivity to 600 microvolts/cm and provides continuous adjustment between ranges. Amplitude ranges appear in illuminated digital form when calibrated.

AMPLITUDE CALIBRATOR:	500 millivolts dc into 50 ohms; ±2%.
SIGNAL DELAY:	Built-in signal delay line in each channel permits internal triggering from either A or B signal and display of full risetime of triggering signal itself.
NOISE: (referred to input)	Less than 1 millivolt, smoothed; less than 2 millivolts, unsmoothed.
INPUT IMPEDANCE:	50 ohms ±1% at dc; up to 10 megohms with optionally available probes.
UNDISTORTED DEFLECTION:	10 cm.
DC OFFSET: (referred to input)	±1 volt; front panel output monitoring jack provides setable 1% accurate voltage for direct measurement with external dc voltmeter. DC offset permits viewing of portions of large signals at maximum sensitivity, or of signals riding on dc levels up to 1 volt.
DISPLAY MODES:	1. Ch. A or B plotted against sweep: 2. Ch. A vertical, Ch. B horizontal (X-Y plotting); 3. Ch. A - Ch. B (differential); 4. Dual-trace Ch. A and B simultaneously, when using dual trace main frames; 5. Dual-trace X-Y.
POLARITY INVERSION:	Polarity of either A or B signal can be inverted 180° for comparison of signals 180° out of phase.
SIGNAL OUTPUTS:	A and B signals brought out at rear terminals. Output approx. 1 to 2 volts for 10 cm of vertical deflection.
PROBE OUTPUTS:	Power provided on A and B channels for operating Type 9009 "HIGH-Z" cathode follower probe.
CONNECTORS:	Universal input connectors (GR locking type, 874 series).

TRIGGER AND SWEEP CIRCUITS

SWEEP RANGE:	0.5 nanoseconds/cm to 2 microseconds/cm, ±3%; uncalibrated vernier increases sweep speeds approximately 3:1 on each range.

SWEEP EXPANSION:	10 times on all ranges. Dot resolution remains constant; ±4% sweep rate accuracy when expanded. Additional 5:1 expansion to 10 picoseconds/cm available with calibrated magnifier in main frame. Sweep ranges appear in illuminated digital form when calibrated.
UNDISTORTED DEFLECTION:	10 cm.
ARMED SWEEP:	Armed single sweep, useful for photography and storage scope displays.
MANUAL SCAN:	Manual scanning of display provided by front panel control. Useful for storage scope display and external X-Y recorder plots.
EXTERNAL SWEEP:	Permits externally scanning the sample display; time/cm remains calibrated; min. 20 volts into 20,000 ohms for 10 cm; adjustable by front panel control.
SWEEP OUTPUT:	Output signal of approximately 5 to 10 volts for 10 cm horizontal deflection available at rear terminal for plotting with external X-Y recorders.
SAMPLES:	Three-position switch gives coarse, medium, or fine dot displays.
SWEEP DELAY:	0.5 ns/cm to 10 ns/cm ranges - up to 100 ns delay; 20 ns/cm to 0.1ns/cm ranges - up to 750 ns delay; 0.2 us/cm to 2 us/cm ranges - up to 5 us delay; as high as 15 us delay with 10 X sweep expansion.
TRIGGER INPUT:	Input impedance 50 ohms, ac, up to 1000 mc; usable to over 5000 mc; either internally or externally triggered.
TRIGGER SENSITIVITY:	External - 15 mv for a 3 ns wide 0.5 ns rise time pulse; up to 1000 mc. Internal - 75 mv for a 3 ns wide 0.5 ns rise time pulse; up to 1000 mc.
TRIGGER OUTPUT SIGNAL:	Amplitude 200 mv min., width 50 ns min, 3 us max.; output impedance will drive 50-ohm dc load.

GENERAL

CATHODE RAY TUBE:	5", flat-faced, Analab Type 5AQPB; metallized screen; operating at 3 kv; provides bright steady traces, even at low repetition rates; 10 x 10 an graticule. Bezel accepts all standard scope cameras. Non-flickering P7 type screen with amber filter - standard; P31, P2 or P11 type phosphors with appropriate filters - optional at no extra cost.
BEAM FINDER:	Quickly locates off-screen traces and facilitates centering on screen.
POSITIONING CONTROLS:	Separate vertical and horizontal positioning controls; separation control for setting relative position of dual-trace displays; in addition to dc offset controls and horizontal delay controls in plug-in.
POWER REQUIREMENTS:	300 w max.; 115 or 230 vac ±10%, 50 to 2000 cps.
DIMENSIONS: (Main frame + Plug-in)	Portable Model - 9" w, 15" h, 22" d Rack-mount Model -19" w, 7" h, 22" d (behind panel) 701 plug-in only -8½" w, 7" h, 13¼" d (behind panel)
WEIGHT: (with Type 1120)	Unpacked - 55 pounds; Packed - 65 pounds
FINISH:	Satin aluminum front panels with color-coded controls.

NOTE: For fast and easy maintenance, Analab Type 9001 service cable is recommended; permits operating Type 701 plug-in completely outside of main frame.

SECTION II.

THEORY OF OPERATION

2.1 BASIC PRINCIPLES OF OPERATION

The waveform displayed on a Sampling Oscilloscope CRT is actually a "slowed down" replica of the input signal applied to the oscilloscope. It consists of a series of samples of the input waveform with each successive sample taken progressively further out in time with respect to a reference trigger zero time. Although the entire horizontal width of the CRT display may represent only a few billionths of a second (nanoseconds) of the actual signal being sampled, the time for the spot (electron beam) to move from left to right could be as much as several seconds. Unlike conventional oscilloscopes, the actual real time for the beam to travel from one end of the screen to the other is relatively unimportant and does not enter into the time calibration of the instrument. With the aid of the block diagram of Fig. 2 in conjunction with the waveforms of Figure 1, the basic principle of operation of a Sampling Oscilloscope is as follows:

A trigger pulse which is derived from the input signal at a particular triggering voltage level starts a Fast Ramp (Fig. 1-c). An extremely fast Comparator compares this fast ramp voltage with a relatively slowly increasing Time Scan Voltage which is also used to "push" the spot across the CRT screen. At the intersection of the Fast Ramp and Time Scan Voltage, a very narrow pulse called a Strobe Pulse is developed. From Fig. 1-c and 1-d it is seen that this Strobe Pulse is delayed more and more with respect to the trigger with each succeeding repetition cycle. The Strobe Pulse is in turn applied to a sampling circuit which effectively takes a slice of the input signal and feeds it to a stretching circuit for display on the CRT vertical plates. In actual practice, for a given repetition cycle the stretching circuit output amplitude is proportional to the input signal amplitude as indicated by the dots in Fig. 1-e. It is held at that level until the next repetition cycle at which time an amplitude correction is made based upon the input signal amplitude at the time the next sample is taken. Because of the finite delays in producing the Fast Ramp and Strobe Pulse and because the trigger is developed from the signal, it is necessary to delay the signal prior to sampling it, in order to permit viewing the initial portion of the signal.

2.2 BASIC SWEEP RATE CONSIDERATION

It is interesting to see just how the Sweep Rate of a sampling oscilloscope is established. The Time Scan Voltage

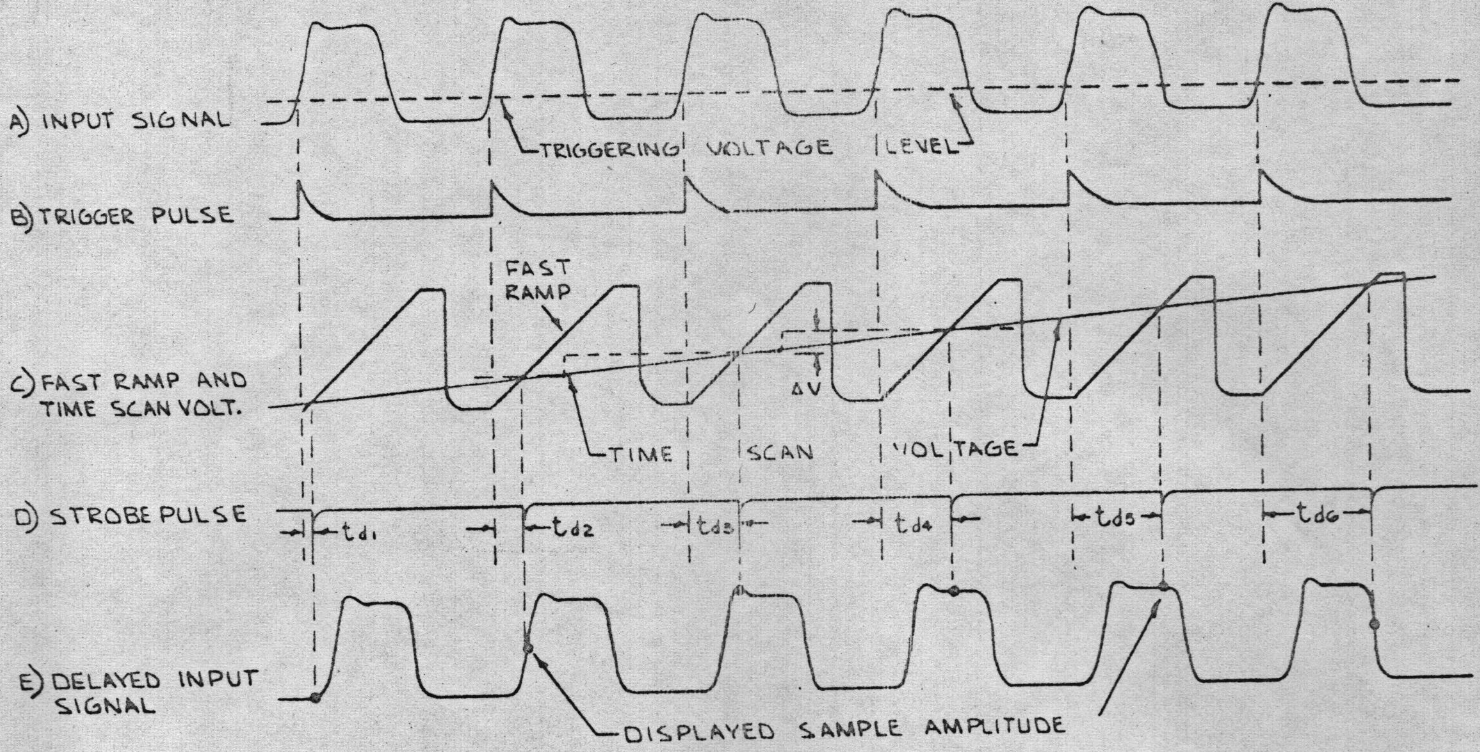


FIGURE 1: BASIC TIMING WAVEFORMS

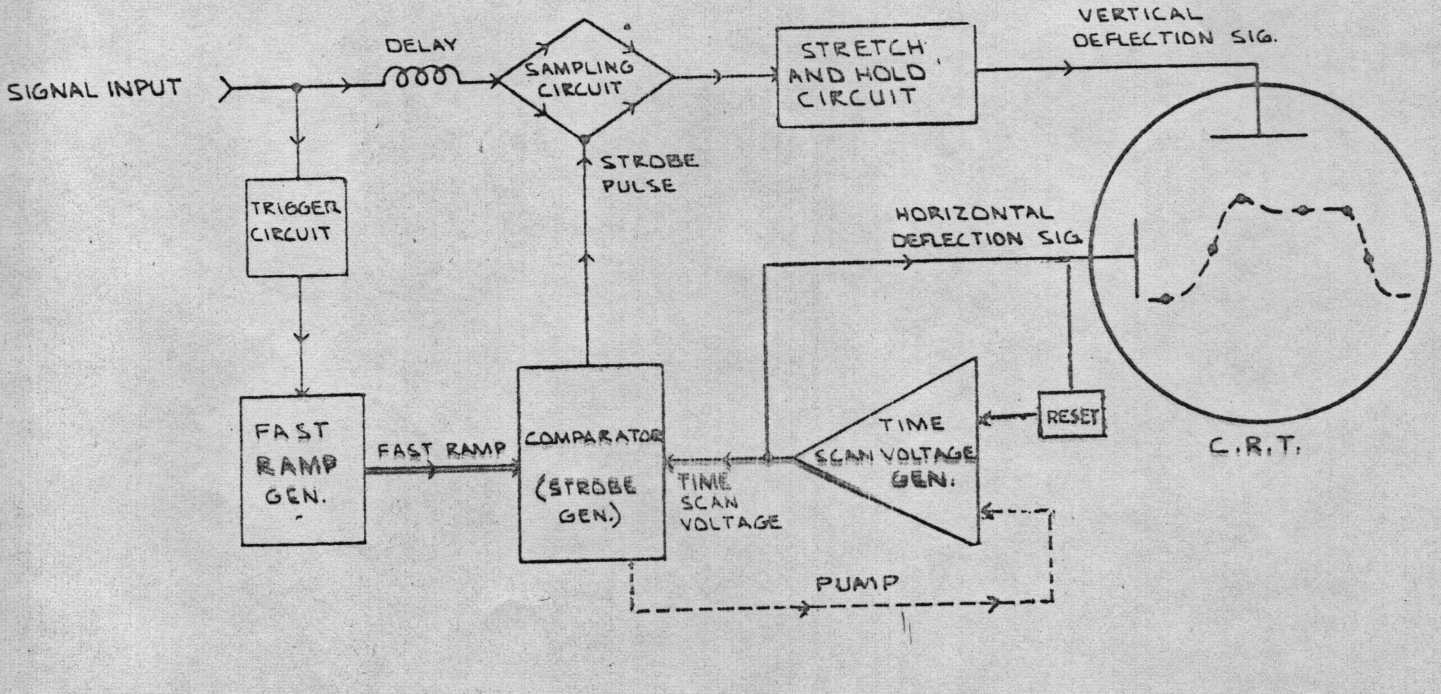


FIGURE 2: BASIC SYSTEM COMPONENTS

Generator output is applied both to the Comparator and to the CRT horizontal plates. At the horizontal plates, it is well-known that a given voltage will move the spot a given number of centimeters. Let us assume that the spot moves 10 cm for 10 volts of the Time Scan Voltage. The Fast Ramp increases in voltage at a predetermined rate, say 10 volts in 100 nanoseconds. The same 10 volts that moved the spot across 10 centimeters of the CRT screen, therefore, moves the Strobe Pulse 100 nanoseconds by picking off different levels of each succeeding fast ramp. The basic sweep rate for the above case is, therefore, 10 nanoseconds per cm.

2.3 SWEEP RATE EXPANSION AND HORIZONTAL POSITIONING

The addition of an attenuator and variable DC voltage between the Time Scan Voltage Generator output and the Comparator input, as in Fig. 3 allows for additional time expansion of the basic sweep rate. Note that the voltage driving the CRT horizontal deflection plates remains the same regardless of the position of either the Sweep Rate Expand Attenuator or the Variable DC Voltage. The attenuator reduces the amount of voltage fed to the comparator while the variable DC voltage positions the attenuated Time Scan Voltage so that Strobe Pulses can be produced only over a particular portion of the fast ramp.

Figure 4 shows three different conditions of the CRT display for 3 separate settings of attenuation and DC voltage shift. In Fig. 4-a there is neither any attenuation or DC shift. The darkened part shows that portion of the Fast Ramp which is scanned by the Time Scan Voltage as it causes the spot to move from one end of the CRT to the other. Three cycles of the input pulse train are displayed at a sweep rate of 10ns/cm.

Figure 4-b shows the situation with still no DC shift but with 5 times attenuation of the Time Scan Voltage. The portion of the Fast Ramp which is scanned is reduced by 5 times and the resulting Strobe Pulse will now move through only 20 ns as the dot travels the CRT screen. The display is, therefore, now 2 ns/cm and expanded around the rise of the first pulse of the train.

In Fig. 4-c the attenuation remains at times 5 but a positive DC shift is added prior to comparison. This allows scanning of the Fast Ramp further out in time, thereby allowing for display of the trailing edge of the 3rd pulse.

The Variable DC shift is seen to provide horizontal positioning of the signal viewed on the CRT. Increasing the DC voltage allows samples to be taken further out in time. The increasing voltage, therefore, causes the displayed signal to move across the screen from the right to the left.

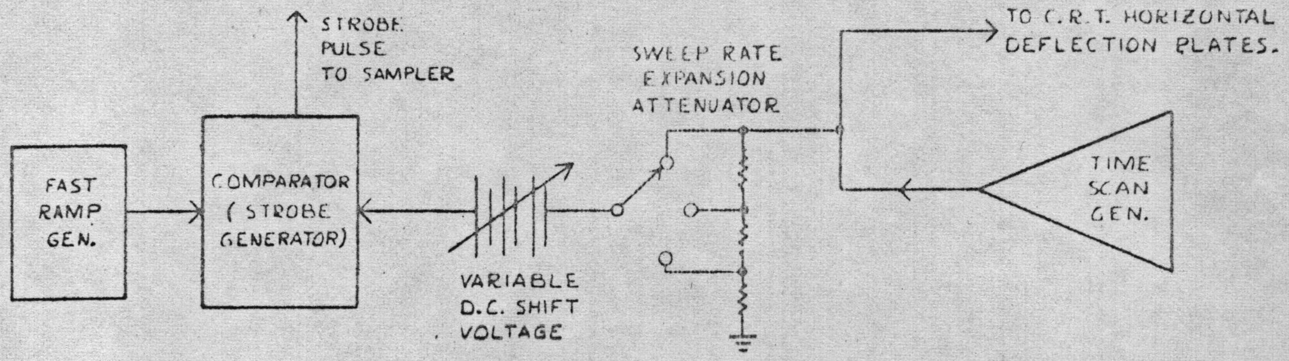
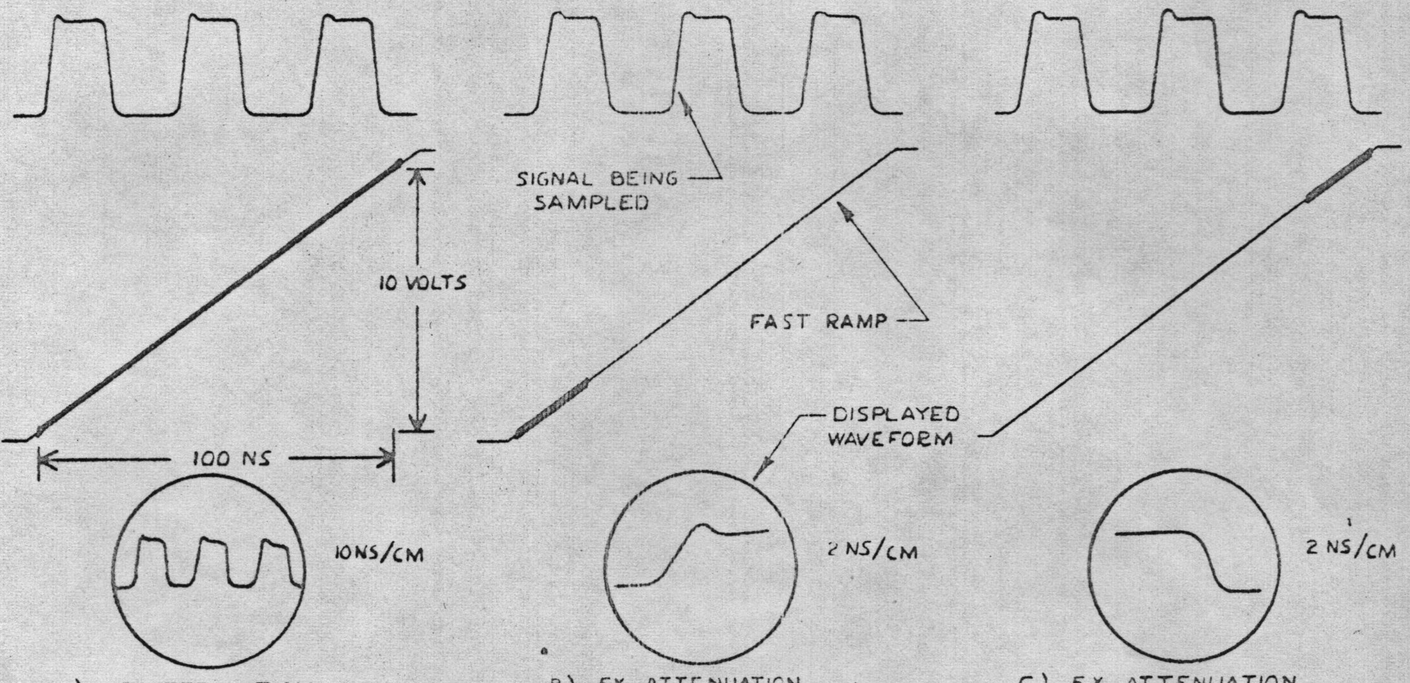

STROBE PULSE TO SAMPLER
FAST RAMP GEN.
COMPARATOR (STROBE GENERATOR)
VARIABLE D.C. SHIFT VOLTAGE
SWEEP RATE EXPANSION ATTENUATOR
TO C.R.T. HORIZONTAL DEFLECTION PLATES.
TIME SCAN GEN.

FIGURE 3: SWEEP RATE EXPANSION AND HORIZONTAL POSITION SYSTEM



A) NO ATTENUATION
NO D.C. SHIFT

B) 5X ATTENUATION
NO D.C. SHIFT

C) 5X ATTENUATION
POSITIVE D.C. SHIFT

FIGURE 4: TIME EXPANSION AND HORIZONTAL POSITION

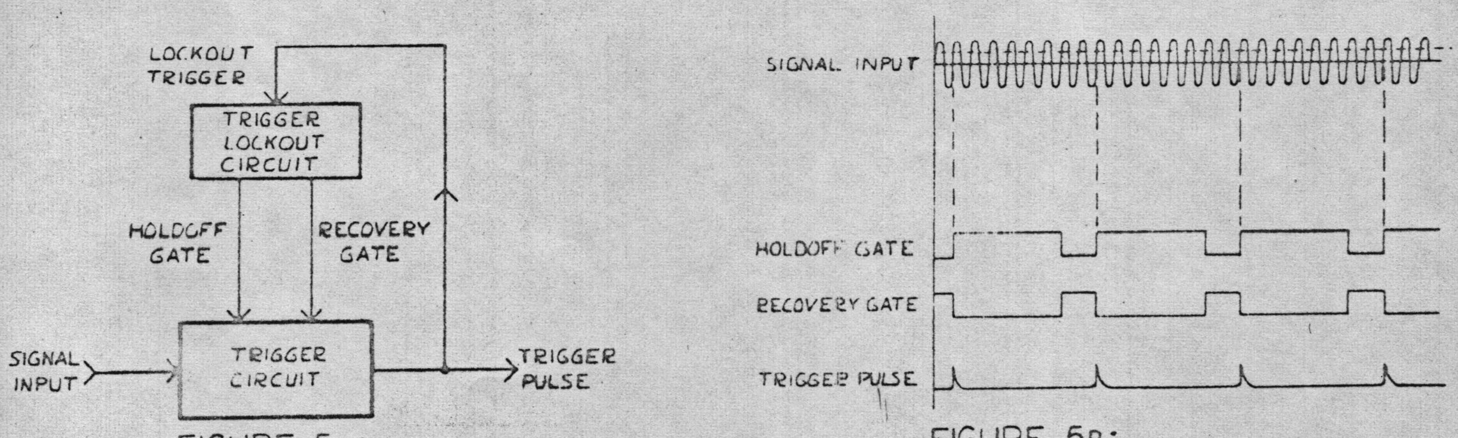


FIGURE 5A:

FIGURE 5B:

TRIGGERING SYSTEM

2.4 TRIGGER COUNT DOWN SYSTEM

One of the basic differences between sampling and conventional oscilloscopes is that in a conventional system a trigger is produced once each horizontal sweep whereas in a Sampling instrument a trigger must be developed prior to each sample. Thus, if the horizontal scan is to be composed of 100 samples per centimeter, 1000 trigger pulses will be required for each horizontal sweep. In addition, for each trigger pulse a Fast Ramp is generated and compared with the Time Scan Voltage to produce the Strobe Pulse. It is essential that both the Fast Ramp and Strobe Pulse circuits be completely recovered before the system accepts a trigger pulse. This requirement limits the maximum rate at which samples can be taken to about 100kc or approximately 10 microseconds between samples. Thus, if the signal to be viewed is a 100 megacycle sine wave, a trigger is generated once for every 1000 cycles of the 100 megacycle input signal. Figure 5 shows the basic blocks and timing necessary to provide for locking out the trigger pulse.

The maximum sampling rate is also limited by the Horizontal Sweep Rate. If, for instance, 10 microseconds/cm is selected, the Fast Ramp must be greater than 100 microseconds and time is required for recovery. Assume, therefore, that a Trigger Lockout Time of 200 microseconds is required, thereby limiting the maximum Sampling Rate to 5000 cycles per second. It is important to realize that this, in conjunction with the desired number of samples per centimeter determines the real time it takes for one horizontal sweep to occur. For instance, at a sampling rate of 5000 cycles per second and a sampling density of 1000 samples per centimeter, it would take 2 seconds to trace out a single horizontal display.

2.5 USE OF STAIRCASE GENERATOR FOR TIME SCAN VOLTAGE

The diagrams so far have shown the Time Scan Voltage to be a slowly increasing voltage relative to the Fast Ramp voltage. The number of samples taken during any one horizontal display would, therefore, be determined by two factors. First, by the real time it takes for the Time Scan Voltage to increase from zero to its final voltage and second by the number of pulses being sampled during that time. This is apparent from observing Fig. 1. The sampling density in dots per centimeter is, therefore, not constant as either of the above mentioned parameters is varied. A constant sampling density is maintained by using a Staircase Generator as a source of the Time Scan voltage. By observing Fig. 1 it should be clear that there would be no difference in the comparison point of each succeeding Fast Ramp and Time Scan Voltage if the Time Scan Voltage was increased by a fixed voltage, V, a short, time after each strobe pulse is generated. The important concept presented here is again tied in closely with the use of the Fast Ramp to produce sample pulses delayed in time with respect to a trigger. A Staircase Voltage Generator increases its output Voltage by a fixed amount each time it is told to do so. The Comparator produces a fixed delay for each fixed increment of reference voltage compared to the fast ramp. The Comparator, in addition to producing a Strobe Pulse for sampling, also generates a "Pump Pulse" after each Strobe Pulse to advance the Staircase Generator a fixed amount after each sample. The time difference, in sampled time, will then be constant from pulse to pulse independent of input repetition rate.

2.6 THE BASIC VERTICAL SYSTEM

The Vertical System to be described is an error sensing feedback system as shown in Fig. 6 which employs a balanced bridge sampler as the error sensing detector. This technique results in very little "strobe feedout" in addition to providing excellent gain stability.

The preceeding sections have explained the method by which a Strobe Pulse is developed and delayed with respect to a trigger in order to establish a horizontal sweep rate. The signal displayed on the CRT is thereby transformed from real time to sampled time. To develop an understanding of the vertical system it is not necessary to consider these time relationships. In fact, it is convenient to analyze the system for a suddenly applied DC voltage (or step) of 1 volt amplitude as follows:

It is assumed that the output of the vertical system at the Memory Amplifier is zero prior to T = 0. This is based upon information from the previous samples. The Sampling Bridge is essentially a fast switch or gate which closes for an instant when the Strobe Pulse is applied. Fig. 7 shows that the voltage at the input to the bridge just prior to the time of the first Strobe Pulse is one volt while the output of the bridge is at zero volts. For the brief instant of time at which the Strobe Pulse is applied to the bridge gate, stray capacity Cs will try to charge to 1 volt. However, because of the bridge conversion efficiency determined by the series resistance of the diodes and the stray capacity Cs, the bridge output will only reach about 200 millivolts. The signal discharges to zero with a time constant of RCs. (Fig. 6) The AC amplifier gain is set to amplify and invert this stretched sample pulse to 1 volt as in Fig. 6.

The Memory Gate may also be thought of as a switch which closes upon receipt of a Pump Pulse which occurs in synchronism with the Strobe Pulse. The Memory is a high gain DC inverting amplifier of very high input resistance (operational amplifier) with capacitive feedback. It is more commonly referred to in standard text books as a Miller Integrator. If it is assumed that the time constant $R_1 C_1$ is large compared to the duration of the Pump Pulse, then all the charge on C1 will be transferred

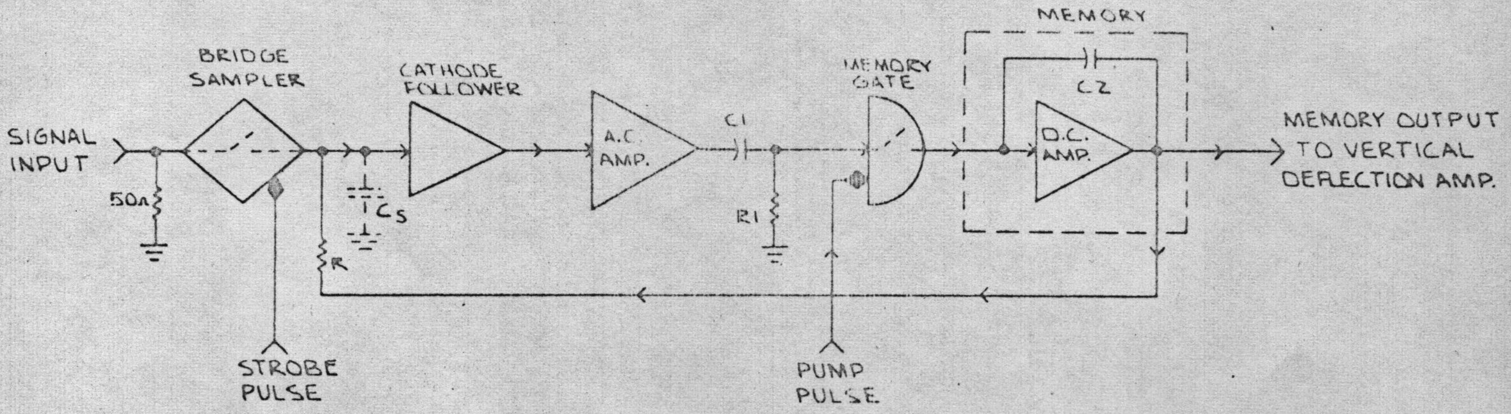
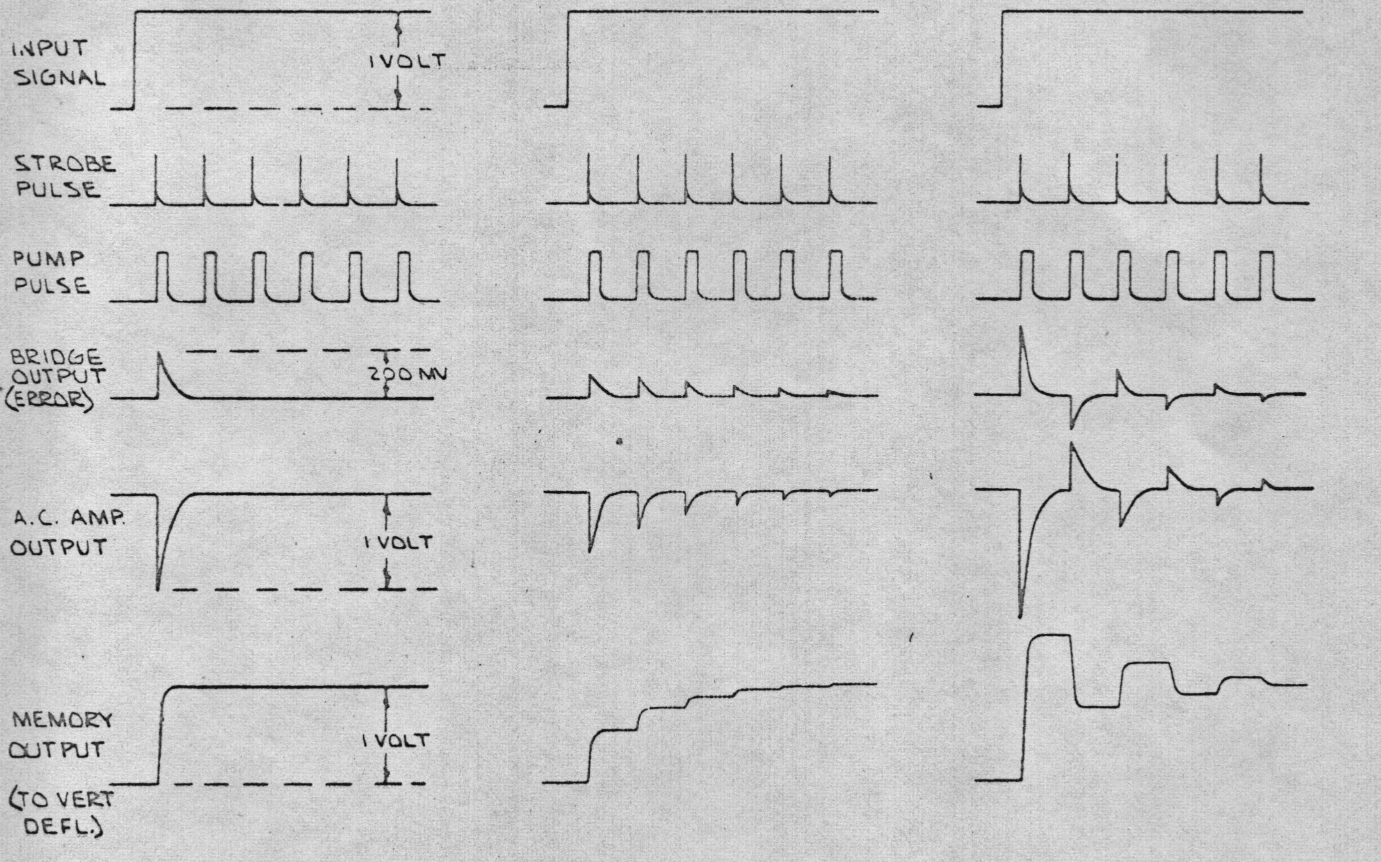


FIGURE 6: BASIC VERTICAL SYSTEM BLOCK DIAG.



A) UNITY LOOP GAIN
NORMAL RESPONSE

B) REDUCED LOOP GAIN
SMOOTHED RESPONSE
(EXPONENTIAL)

C) INCREASED LOOP GAIN
OSCILLATORY RESPONSE
DAMPED

FIGURE 7: VERTICAL SYSTEM TIMING WAVEFORMS

to C2 upon receipt of the Pump Pulse at the Memory Gate. This causes the memory amplifier output to go to plus one volt. The output will remain at this level until the next sample is taken. At this time it will either stay the same or change depending upon whether or not any difference exists between the actual output fed back to the Bridge and the input to the Bridge. For the case shown in Fig. 7a, at the time of the second sample, there is no difference voltage across the Bridge and, therefore, the Memory output remains at one volt.

The above system has an overall conversion gain of unity, or in other words, for a 1 volt input signal the Memory output will be one volt. By the addition of two simple ganged resistive attenuators as in Fig. 8 the conversion gain can be varied thus allowing a simple method of setting the Oscilloscope Sensitivity in millivolts/cm.

To examine this let us assume that the input step is now 10mv with S1-A and S1-B positioned as shown in Fig. 8. If the output based upon the last sample prior to the input voltage step is again assumed to be zero, then the bridge output will be 2mv after the first sample. If the AC amplifier gain is now increased so that its output is a 1 volt pulse, the Memory will again go to 1 volt. S1-A is set, however, to feed back only a portion of the memory output. For instance, if the attenuation is set for 1/100 then 10 millivolts will be fed back to the bridge. The voltage across the Bridge at the time of the second sample is, therefore, zero and no error signal will be developed. The output of the Memory will remain at 1 volt. The conversion gain for the above case is 100 inasmuch as the output has changed 1000 millivolts for a 10 millivolt input signal.

It has been demonstrated that, for a step input, the output will always reach a steady state value equal to the input divided by the proportion of the Memory Output fed back to the Bridge as established by S1-B. The output will reach the final value in one sample provided the gain around the feedback loop is maintained at unity as in the two examples above. S1-A is ganged to S1-B for the purpose of maintaining the loop gain unity independent of the overall conversion gain as set by S1-B.

2.7 DOT TRANSIENT RESPONSE AND SMOOTHING

It is interesting to examine the affects of varying the loop gain from unity by reducing the forward loop gain as set by the AC amplifier. Fig. 7B shows the effect of reducing the gain to one half of its value for unity loop gain. It is observed that the first sample error is less than that for the unity gain case. The Memory output will, therefore, not reach 1 volt in 1 sample. During successive samples the error is reduced as shown in Fig. 7B. It, therefore, takes many samples for the output to reach its final steady state value. This situation is referred to as Smoothing. The affect of Smoothing is such that every sample is not a true sample. Smoothing has the advantage of decreasing the affects of random noise. It does, however, also decrease the transient or dot response of the vertical system. If the sampling rate is such that there are many samples closely spaced for a given change of input signal, the actual "loss of information" due to the reduced transient response can be made very small at a considerable increase in overall noise performances.

Figure 7C shows the condition of underdamped or oscillatory transient response which results when the loop gain is set at about 50% higher than the desired value. Here it is noticed that the error signal is reversed in direction after each sample causing the output to oscillate in decaying amounts until a steady state value is reached. If the gain is set to a value equal to or greater than twice the required value the system will be completely unstable. In actual practice the overall loop gain is held tightly at unity by extensive use of feedback in the associated amplifier circuits. The important concept presented above is that the feedback system always tends to reduce the error across the Bridge to zero.

2.8 D.C. OFFSET VOLTAGE

The feedback system described above can be further modified to introduce a dc offset voltage. The dc offset voltage will control the level of the output voltage to allow observation of small variations of an input signal which itself has a high dc level. For example, suppose it is desired to observe a 10 mv ripple on top of a 2 volt pulse. This is accomplished by adding to the feedback voltage a dc offset voltage as in Fig. 9. If we consider the case for zero signal input to the Bridge and zero output of the Memory prior to the next sample, a sudden change in the offset voltage will produce an error signal across the Bridge which in turn causes the Memory output to assume a new value. The nature of the system is such that the Memory output must reach a voltage which equals the value of the offset voltage multiplied by the attenuation ratio of S1-B.

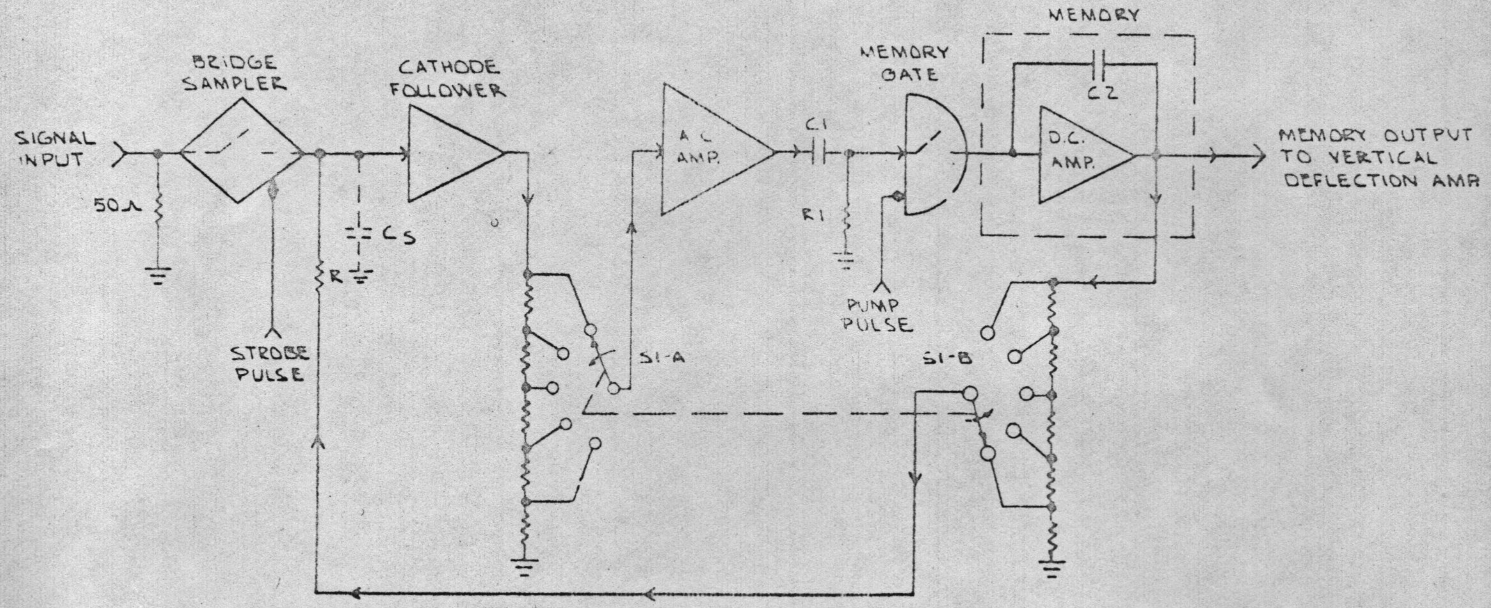


FIGURE 8: VERTICAL SYSTEM WITH GAIN SWITCH

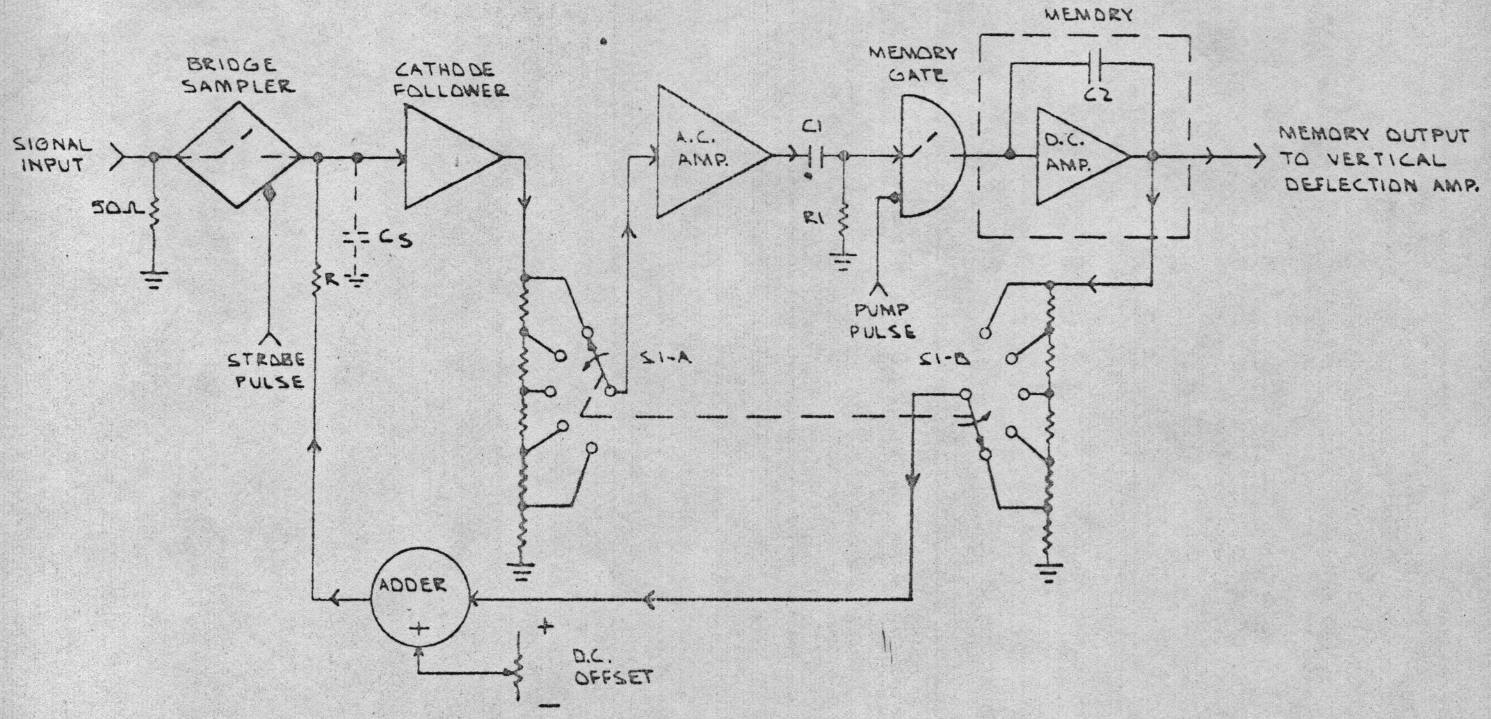


FIGURE 9: VERTICAL SYSTEM WITH D.C. OFFSET

SECTION III.

UNPACKING AND INITIAL TURN-ON

3.1 UNPACKING PROCEDURE

After carefully removing the 701 from its carton, check that all plug-in boards are tight in their sockets, that all transistors are well pushed into their sockets, and that no loose parts are in the unit. Check the 115/220 switch on the rear panel to see that it is in the 115 position unless a 220-volt source is being used to power the Analab frame. After these initial checks, the 701 may be plugged into a standard Analab frame, either Type 1100, 1120, or 1220. Be sure the unit is plugged all the way in and then tighten the finger lock on the lower center of the plug-in.

3.2 INITIAL TURN-ON PROCEDURE - (Step-by-step, described for Dual-Trace Type 1120 Main Frame with Type 701 Plug-in).

1. Set dual-trace main frame Y position and AB separation controls to the center of their ranges and turn Y display function to A. The AB separation and Y-display function controls do not exist in single-trace main frames.

2. Turn intensity control to low intensity.

3. Set X display function to sweep (on A swp in single-trace frame) and X position to approx. the center of its range.

4. 701 Vertical controls

   a) Set var. gain to calibrate on A & B channels.
   b) Set volts/cm to 200mv/cm on A & B channels.
   c) Set smoothing controls to off (ccw); this is a detent position.
   d) Set DC offset to center of its range.
   e) Set A, B differential switch to off (down).
   f) Set normal - invert switches to normal on A & B channels.

5. 701 Horizontal Controls

   a) Set sweep time/cm to 10 ns/cm.
   b) Set variable sweep time/cm to cal. (ccw).
   c) Set Sweep Source switches to Int.
   d) Set Man Scan pot on a sweep source sw. to ccw.
   e) Set samples switch to FINE.
   f) Set sweep delay to center of its range.
   g) Turn level control to full cw (most important step).
   h) Set trig. source switches to A, Int., Minus.

The 701 unit is now ready for operation with a negative input signal applied to A channel.

6. Turn Analab frame power switch on.

7. Turn beam finder, in upper left-hand corner, clockwise and hold.

8. Slowly increase intensity until a horizontal line is visible on the screen.

9. Center the horizontal line using the vertical display controls on the Analab frame.

10. Release the beam finder and again center the trace with the Analab frame controls.

11. Focus trace to desired crispness.

12. Turn A channel dc offset control cw and then ccw and note that trace moves smoothly up and then down four cm or more. This check verifies that the 701 system is operating properly on the A channel side.

13. Turn the Analab frame Y display function to B and vary the B channel dc offset control just as was done in step 12 for A channel.

14. Turn the Analab frame Y display function to Alternate. Both A & B traces should now be visible and should respond to changes in their respective D.C. offset controls.

15. Connect a BNC to GR cable from the trig. out pulse to A channel input.

16. Turn the sweep delay control toward full cw. The trig. out pulse should be visible on the screen and should move to the right as the sweep delay control is moved CW.

17. Remove the trig. out signal cable.

18. Desired signals may be applied to the 701 and the trig. level control adjusted to give the best lock.

19. The sweep delay control and its vernier should be used to position the signal to the desired spot on the screen.

20. The stability control may be used to improve the lock, if necessary.

21. If it is desired to display signals on B rather than A and/or trigger from an external source, the trigger source switch and Y function switch should be set properly.

SECTION IV.

INPUTS AND OUTPUTS

4.1 FRONT PANEL INPUTS

1. The most important inputs on the 701 front panel are the A & B signal inputs through the GR-874 locking connectors.

   The dc input impedance to ground is 50 ohms, ±1%. The linear input signal range is ±1 volt.

   Signals of ±2 volts are displayable. Max. input signal should be restricted to ±5 volts.

   Signals up to 700 mc will be displayed within 3 db accuracy and signals above 1kmc may be easily viewed.

2. Ext. Trig. input

   Input impedance is approx. 50 ohms, a.c.

   A signal of approx. 15mv and 3ns wide (or faster) is required to trigger the 701 externally with 0.1 ns time jitter. Max. trig. input should be limited to ±1 volt to avoid trig. damage.

   Approx. 70 mv external trig. input will provide very clean sine wave locking to well above 10 mc. Up to 400 mv may be required for very clean locking to 700 mc and above.

   a) Note on Internal triggering

      The user will often elect to internally trigger the 701 from either A or B channel by choosing the desired trigger source switch arrangement. Internal triggering is approx. 1/6 as sensitive as external triggering throughout the frequency band. The internal trigger takeoff operation is one of the sterling features of the 701 sampling converter.

3. External sweep input

   The input impedance is approx. 20 ohms. The required input voltage swing is a min. 2 volts/cm horizontal deflection. This sensitivity is obtained with the Man. Scan Ext. Sweep Atten. pot, on the Sweep Source Switch, turned fully cw. Input signal should swing positive from zero volts for left to right deflection.

   Input sweep need not be a sawtooth. For example, a level-shifted sine wave at 60 cycles would be satisfactory. (However, in this case, the left portion of the trace will be brighter than the right due to the blanking circuit backlash.)

Max. input frequency should be restricted to 120 cycles/sec. and max. input voltage should be restricted to between +50 and -10 volts.

4.2 FRONT PANEL OUTPUTS

1. Trig. out Pulse

This is a negative pulse with 2ns risetime between 20-80% points, 200 mv or more amplitude which occurs in synchronism with the trigger recognition function of the 701. The pulse is designed to drive a 50 ohm load. Max. rep. rate of this sync out pulse is approx. 40 kc in the fastest eight sweep time/cm switch positions and 15 kc in the slowest four sweep rate switch position.

The trig. out pulse is designed to synchronize external equipment to the 701, e.g. tunnel diode pulses.

2. DC offset voltage (A & B)

Output impedance approx. 25k ohms. This output should be monitored only with a high impedance voltmeter. Output voltage swing has been factory set to give ±10 volts output with 10% accuracy as the respective front panel. DC offset pot is used to move the trace ±1 volt on the screen. This voltage may be set to 1%. If the response, balance or gain of the unit is changed, the internal calibration pot. must be changed. Once calibrated, the dc offset voltage may be used to make precise amplitude measurements by the null method. For example, the top and bottom of a pulse may be successively positioned to the same point on the screen by using the dc offset voltage. Difference in dc offset voltage readings is equal to ten times the pulse amplitude.

3. Trig. feedout from ext. trig. input.

Trig. feedout from the ext. trig. input of the 701 is typically 5mv, 3ns wide. This is remarkably low for such a sensitive and wide band circuit.

4. Voltage Calibrator - clamped 10 mv current source (500 mv calibrate into 50 ohms dc).

The 500 mv dc calibrate output voltage is developed into 50.0 ohms by a 16.5 k 1% resistor operating from the -165v supply in the Analab frame. The output is clamped to approx. -3 volts when 50 ohms is not connected to it. This output is intended to be used in calibrating the 701 vertically. If a precision 50.00 -ohm and a precision dc voltmeter are available, the 500 mv dc cal may also be used to check the dc impedance of the 701 or other 50-ohm systems.

5. The probe power output on the front of the 701 provides +250

at 20 ms, on Pin 2; -20V at 50 ma on Pin 3; and -3 volts at up to 300 ma between the +15 and -3 volt supplies on Pins 1 & 4. This is intended for use in operating probes and pulse gen. accessories to the 701. The connector mate is a Hirshman MAS-5.

4.3 REAR PANEL OUTPUTS

NOTE: A number of outputs are on terminals on the rear of the main frame. The same terminals are used for different functions for other plug-ins.

1. Both A & B channel outputs are brought to the rear of the 701 to wires which pass through the 1120 frame to the rear terminal strip. A is on the 3rd terminal from the left on the rear terminal board of the main frame. On older frames in the field this terminal is marked EXT CAPACITOR (left terminal). The B channel output is on the 5th terminal from the left. It is marked MAN SWITCH on older frames. The loading placed on these terminals should not be heavier than a 20k load resistor.

   The output voltage swing is slightly greater than 100mv/cm vertical deflection on the crt. Satisfactory connection of these outputs through the 1120 frame may be verified by monitoring the desired output with a voltmeter while moving the respective front panel dc offset control.

2. The staircase horizontal sweep is also brought to the rear of the 701 and through the main frame. The output load resistor should be 20k-ohm or larger. The output sweep voltage is on the 6th terminal from the left. It is marked SAW OUT on older frames on the rear of the main frame. Verification of proper hookup of this line may be made by placing the front panel sweep source switch into the manual scan position and moving the manual scan pot cw and ccw while monitoring the rear staircase output with a voltmeter.

   The A, B, and X staircase outputs are intended to be used in driving an X-Y plotter for voltage vs time or Lissajous patterns. The unit must be triggering for these outputs to operate properly. The main frame horiz. and vert. controls have no effect on these outputs. In addition the internal vertical gain calibration of the 701 has no effect on these outputs.

3. 701 outputs to the 1120 frame

   a) A and B vertical deflection at approx. 40 mv/200 mv input signal at min. sensitivity adj. by internal 701 gain pot. Output impedance approx. 2000 ohms. Pins 1 and 17 for A and pins 16 and 32 for B channel on the rear Amphenol connectors of the 701.

b) Horizontal deflection

Approx. 2 volts for full scale (10 cm deflection) when loaded with 2K impedance. (Pin 27 of upper Amphenol connectors on the rear of the 701).

c) Unblanking signal

+20v to +100v signal synchronized to provide proper blanking operation and designed to drive 33k to ground. (Pin 5 of lower Amphenol connector on rear of 701.)

4.4 REAR PANEL INPUT TO THE 701

1. Remote single sweep

A wire paralleling the front panel armed sweep button is brought out to the rear of the 701 plug-in (pin 10 Upper Amphenol connector) and through the main frame to the rear terminal, 7th from left, on the 1120 (when the 701 is plugged into the main frame.) On older units this is the right terminal for the manual switch contacts.

When the front panel sweep source switch is placed in the "armed" mode, a relay closure of this wire to ground will cause the 701 to make a single sweep in just the same manner as pressing the front panel armed button. The standing dc voltage on this wire before closure is +20 volts through 10 k ohms.

4.5 REAR PANEL POWER INPUT TO THE 701

1. 115/220 ±10% at 1 amp to ½ amp (depending on setting of rear panel 115/220 switch) 50 cps to 2000 cps

2. + 250v, 100 ma

3. + 100v, 10 ma

4. - 165v, 10 ma

5. + 9, 300 ma

6. - 3, 450 ma

6A +15, 750 ma

7. 6.3 vac 2 amp

Pins on 701 rear amphenol correspond to power connectors on Analab Type 1120 and 1220 frames.

SECTION V.

FRONT PANEL CONTROLS

The front panel controls of the 701 plug-in unit are designed to complement the controls of the main frame in such a way that the maximum display flexibility and minimum duplication is obtained.

5.1 1120 FRAME CONTROLS

The Y display function can be used to select either A or B traces from the 701 for display. Either chopped or alternate A, B can be used to display both A and B simultaneously. However, alternate is preferable since less noise and switching serrations appear on the display. The advantage of using chopped mode in a conventional scope, i.e., common time on a particular sweep does not apply to the sampling plug-in operation since the trace alternates every other dot rather than every other sweep.

The A vs B display function can be used to display Lissajous patterns. The vert. position controls, Y pos. and A/B separation can be used to position the display at least two screen diameters if the 701 dc offset controls have brought the trace to within the range of the vertical controls. For high sensitivity settings of the 701, e.g. 2mv/cm the vertical frame controls will provide vernier adjustments for the display. Where it is desired to change vertical gain of the 701 plug-in, it is better to use the frame vertical positioning, rather than the 701 dc offset, to avoid trace shifting due to dc balance changes. An example of the proper use of the dc offset and 1120 frame vertical position will be given when the dc offset is discussed.

The beam finder on the 1120 is especially useful in locating the trace on the 1120 when the 701 is set to high gain and the dc offset is used for coarse positioning of the trace.

The power-on light in the 701 responds to the main frame on-off switch. The intensity, focus and scale light controls on the 1120 frame control the CRT beam display as with ordinary oscilloscope operation.

5.2 DISPLAY NOTES

It should be noted that the trace intensity may vary considerably with the operation of the 701, especially when a P-7 screen is used as the 1120 CRT. A screen burn can occur readily if a high rep rate trigger is removed from the 701 and the trigger level is counter clockwise, such that the spot sits in one place on the CRT.

If it is necessary to operate the instrument in this manner often, the spot may be caused to drift slowly to the right or the left, in the absence of trigger, by changing the internal staircase balance pot. This is on the right side of the 701 plug-in unit near the top of the UPS board. (This will have a slight effect on the samples/cm.)

A "lost" trace may occur as follows: If the 701 is observing a relatively low rep rate pulse such as from a mercury pulser and the trig. level is now advanced clockwise to cause the 701 to run at its own max. internal rate, approx. 40kc, the trace may disappear due to the characteristics of the P-7 phosphor. Turning up the intensity slightly will again bring the trace into view.

These effects may be less apparent with other phosphors. However, the P-7 high persistence phosphor provides a much superior display especially on low rep. rate pulses. The controls on the front panel of the 701 are arranged as follows:

The vertical controls for A channel are arranged directly above the A channel input. Similarly, the vertical controls for B channel are arranged directly above B channel input. Gain (volt/cm) controls are on top. Positioning control (dc offset) is below the gain control and the normal/invert switch is just above the input connector. The A, B differential switch is located directly to the right of the A channel dc offset positioning control.

The horizontal controls are located generally in the center of the front panel. On the bottom are the trigger source selector switches. Just above and to the right are the trig. level and stability pots. Above the trigger source switches and to the left is the sweep delay pot with its vernier. This is used for horizontally positioning a pulse on the screen or viewing the second or later pulses in a train of pulses.

In approximately the middle of the front panel there is the sweep source switch mounting the manual scan/ext sweep atten. pot.

Just to the right of the sweep source switch is the armed single shot pushbutton.

In the top center of the panel is the time/cm or sweep rate switch mounting a variable rate pot. To the right of the time/cm switch is the X10 sweep expander switch. To the left of the time/cm switch is the samples switch to select display coarseness. Attention to human engineering factors has placed the most often used controls near the outer perimeter of the instrument panel, and caused them to be grouped and identified functionally.

The function and proper operating procedure for the individual controls is described in the following sections.

5.3 VERTICAL CONTROLS ON 701

5.3.1 VOLTS/CM SWITCH AND POT

The 701 has a volts/cm switch for A channel and one for B channel. These switches select the sensitivity of the channel in seven steps from 2mv/cm to 200mv/cm, increasing sensitivity clockwise.

There is a variable pot. on each switch which increases the gain of the channel approximately 3 to 1. When the variable pot. is turned counter-clockwise to the calibrated position, a light illuminates the proper volts/cm switch setting. In the uncalibrated position, the light is out. When maximum sensitivity is employed, some baseline noise may appear. This noise is usually readily distinguishable from the signal.

5.3.2 DC OFFSET

1) It provides the DC offset of - 1 V to + 1 V. This means that you can view the tops and bottoms of very large signals at maximum magnification and minimum distortion. You will find this one of the most useful controls in the instrument. It can also be used to compensate for waveforms containing a dc component up to 1 volt.

   For example, when making risetime measurements, the dc offset may be used to position the trace such that the baseline remains fixed when the variable gain control is adjusted to provide 10 cm deflection. Actual vertical positioning of the trace may then be accomplished with the 1120 frame control.

   A single turn pot is used to let you scan rapidly through a vertical signal. Note that at full sensitivity the control can become quite sensitive. The 1120 frame Vert. Position control can then be used for accurate positioning.

2) The other function of dc offset is to provide a precise means of amplitude measurements. The offset monitoring jacks, located next to the dc offset controls, have an output of approximately 10 v per volt of signal input. In order to make an accurate amplitude measurement, it is recommended that the dc offset be calibrated with a precision signal source of one volt or less, dc to 100kc connected to the input, and a digital volt meter connected to the dc offset terminal. Highly accurate waveform measurements can then be made based on this calibration.

5.3.3 SMOOTHING -

Reduces noise by a factor of about 4 to 1. This does not affect the accuracy of time measurements, but can affect wave-shapes and amplitudes, particularly when there are few samples/cm. The smoothing control should, therefore, be used only when necessary, and always with caution. The smoothing control has a positive shut-off, ccw. Full smoothing is cw.

5.3.4 NORMAL/INVERT SWITCH

A normal/invert slide switch for A and B channels, respectively, is located directly above the appropriate input connector. This switches the single-ended 701 output lead with ground as seen at the rear of the 701. Applied to the differential input of the 1120 frame, the result is to invert the trace on the 1120 crt.

Care should be taken when using the normal/invert switches (and all other slide switches on the 701) to close it firmly to one position or the other. An intermediate position will result in a very noisy trace since the 1120 vertical amplifiers will see an open circuit.

5.3.5 A, B DIFFERENTIAL ON MAIN FRAME A DISPLAY

This switch allows both A and B Channels of the 701 to be applied to the main frame A differential amplifier. The result is A & B differential viewed when the vertical display function is in A channel position. The display may also be inverted by use of the A channel normal invert switch on the 701. The B channel invert switch will affect only the B display and will operate the same independently of the setting of the A-B differential switch.

A plus B sum is not available with the combination of the 701 and 1120 frame.

5.4 HORIZONTAL CONTROLS

5.4.1 TIME/CM SWEEP RATE SWITCH

This switch is used to select the desired time base in the range of 2 us/cm fully ccw, to 0.5 ns/cm fully cw. There is a variable pot. on the sweep rate switch which increases the sweep speed approximately 3 times (faster sweep speed cw.) When the variable control is in the ccw or calibrated position, a light in the window above the time/cm switch will illuminate the proper time/cm setting.

5.4.2 SWEEP EXPAND SWITCH

This switch allows expansion of the basic time/cm indicated in the window by a factor of ten. (The var. time/cm pot. expands sweep speed much less than 3 to 1 with X10 expander in.) The X10 expander is most useful for examining waveforms delayed in time. The desired pulse is moved to the left side of the trace by means of the sweep delay pot. and then the X10 expander is pressed down.

Expansion is about approx. the left end of the trace and occurs with no loss in dot resolution, i.e. samples/cm constant.

5.4.3 SAMPLES SWITCH

The samples switch selects the density of the dots. The coarse, medium and fine settings of the switch represent approximately 5, 50, 100 dots/cm when the unit is free-running (trig. level cw) and the internal staircase balance is set to drift very slowly (1 cm/10 sec.) to the left in the untriggered mode.

The coarse position will be found most useful when observing low rep. rate pulses. It is also useful for checking the internal smoothing adjustments in the A and B Channel amplifiers. If several cycles of a sine wave are viewed on the 1120/701 with the respective A or B external smoothing control turned to off, the amplitude of the sine wave should change only slightly as the samples switch is moved from fine to coarse. A large decrease in amplitude indicates insufficient forward gain and possible pulse infidelity. A large increase in amplitude indicates under smoothing and possible noisy unit operation. (Proper setting of the internal smoothing adjustment will be discussed in Section 6.)

For most applications, the fine setting of the samples switch will be found satisfactory.

5.4.4 SWEEP SOURCE SWITCH AND MAN SCAN/EXT SWEEP ATTEN. POT.

The sweep source switch is a four position switch controlling the horizontal spot displacement. For normal operation, the internal position is used and the sweep is derived from the staircase generator within the 701. The samples switch operates as described previously. The external position allows the 701 sweep to be driven by an external voltage applied to the front panel input marked ext. sweep. A positive voltage of 0 to +20 volts will drive the spot across the screen from left to right when the ext. atten. pot. is C.W.

The armed position allows the 701 to make a single sweep on its internal staircase when the "armed" button is pushed or when the rear armed closure is excited. The armed light in the armed button turns on when the sweep source switch is turned to the armed position.

The manual scan position allows the spot to be advanced normally across the screen by the manual scan pot. CW advances left to right. If the manual scan is advanced fully CW the blanking circuit will operate and dim the trace. The blanking circuit will release when the manual scan control is returned to CCW.

5.4.5 ARMED PUSHBUTTON

This switch lights when the Sweep Source Switch is placed in the armed position. Depressing this button will cause the 701 to make a single sweep.

For all operations characterized by the sweep source switch, the 701 must be triggered or free-running.

5.4.6 SWEEP DELAY AND VERNIER

The sweep delay control causes the pulse display to move to the left CCW or right CW. This will be used very frequently for horizontally positioning the display on the time base.

Note: There may be a small amount of non-linearity at the beginning of the sweep delay range when full cw. It is suggested that precise measurements be made away from the full cw position and at the center of the screen. In making risetime measurements for example, one should use the fastest possible setting of the sweep rate switch rather than the slowest. If it is necessary to use a slower range, then it is advisable to look at the second or third pulse in a train and use the sweep expander.

The sweep delay available is a minimum of 100ns on the fastest five sweep rate switch settings; at least 750 ns on the next three sweep rate switch settings (20ns/cm to 100ns/cm) and at least 5 us on the ranges (200ns/cm to 2us/cm). When using the X10 expander, at least 15 us delay is available on the 200ns/cm to 2us/cm range.

5.4.7 TRIGGER SOURCE SWITCHES

These switches allow selection of trig. from A or B channel internally. In addition, external trig. may be chosen. Finally, plus or minus polarity triggering may be selected. Best hi-frequency triggering will occur in minus polarity. An exception occurs if a large trigger input is used in which case the plus polarity may provide best high frequency triggering.

Too large a trigger input amplitude may cause difficulty in lock as well as too small an amplitude.

5.4.8 TRIG. LEVEL AND STABILITY CONTROL

The trig. level more than any other control influences the horizontal operation of the 701. In the trigger input range above 10mc and below 10kc, the trig. level alone may be used to obtain a stable clean lock. In the intermediate range, and for fine tuning, the stability control may be used. This varies the trig. holdoff period slightly. The proper use of the trig. level is to advance it fully clockwise until the unit free-runs continuously and then to back off slowly until a stable trace is displayed. For high frequency sine waves, several lock points may be found. In general, the one furthest ccw will provide best long term locking properties.

Note: Increase or decrease the trigger amplitude if a good lock cannot be obtained using level and stability controls.

SECTION VI.

INTERNAL ADJUSTMENTS

6.1 GENERAL

An attempt has been made to minimize the number of adjustments in the type 701 plug-in unit. Those adjustments included are designed to be functional and directly applicable to some facet of the unit's operation. Check-out and alignment of the 701 sampling plug-in should be done in the following order:

1) All voltages internal to the unit and supplied to the unit from the main frame or other source be adjusted to within the specified accuracies.

2) The main frame horizontal and vertical gain should be set correctly. See the main frame instruction manual for proper procedures.

3) The unit should be time-calibrated using standard frequencies.

4) The sweep start adjustment should be set to exclude non-linear time.

5) The sweep length should be set to 10 cm horizontal.

6) The staircase balance should be set for low drift in the untriggered mode.

Going now to vertical adjustment:

7) The risetime of the sampler should be set using the strobe amplitude and response controls on the sampler board.

8) The sampler balance for A & B respectively, should then be set under maximum vertical sensitivity conditions.

9) The amplifier memory balance for A & B should be set near min. vert. sensitivity conditions.

10) The amplifier memory dot response should be set correctly for A & B

11) The vertical amplitude pots for A & B channels should be set to give correct vertical display on 701.

12) The dc offset gain pot for A & B should be set to provide 10 volts deflection for 1 volt signal deflection with front panel dc offset pot.

The required adjustments, except perhaps for the ±20 volt internal supplies, can be made while the 701 is plugged into the 1120 frame. However, the use of the type 9001 service cable is recommended for convenience.

6.2 VOLTAGE ADJUSTMENT

+20V = meter between (−) TP1 + (+) TP2
-20V = adjust R6

The internal plus and minus 20 volt supplies on the 701 are adjusted by pots on the respective plug-in boards. The 701 must be turned upside down for these boards to be accessible as they are plugged into the 701 from the bottom. The voltages should be adjusted to ±3%. All voltages from the 1120 frame should be checked for their specified accuracy. The +250 volt is used in time calibration in the 701 and the -165 is used for the calibrated output voltage on the front panel.

6.3 FRAME ADJUSTMENT

The vertical sensitivity of the main frame should be adjusted to 40 mv/cm or 400 mv/10cm. The horizontal sens. should be set to 40 mc/cm or 400 mv/10cm using the frame controls on the opposite side. The vertical input voltage to the main frame may be applied directly if the 9001 service cable is used. Otherwise, the input voltage may be varied by moving the dc offset of one of the channels while the unit is being free-run. This voltage can be monitored at the lower outside contact on the normal invert slide of the particular channel. The horizontal voltage is most easily supplied through the 701 horizontal deflection circuit. The sweep source switch should be set to manual scan and the front panel manual scan pot turned to produce a horizontal deflection of the trace. This voltage can be monitored at pin H on the UPS board on the right side of the 701 plug-in unit.

Setting the frame voltages and X-Y sensitivities to within 1% will allow rapid interchange of the 701 with other plug-ins with no recalibration required.

6.4 TIME CALIBRATION

There are three time bases used in the 701 plug-in and there are three adjustments. The first adjustment, the calibrate pot on the UPS board, adjusts all three time bases in the same direction. This calibrate pot. may be used to change the entire unit calibration when going from one main frame to another. The other two adjustments are trimmer capacitors on the sweep rate switch. These adjustments affect only their respective time bases.

The sweep rate switch should be set to 1ns/cm and a 1 mc sine wave or pulse train applied to either channel of the unit. The calibrate pot should then be set so that 9.5 to 10.5 cycles of the sine wave are visible in 10 cm of the trace. There may be slight non-linearities in the sweep. Therefore, the calibration should be checked at several settings of the sweep delay controls excluding the ends. This is especially true if precise measurements are to be attempted.

Next the sweep rate switch should be set to 0.1 us/cm and a 10mc sine wave applied to the input. The large trimmer on the sweep rate switch may then be set to give 9.5 to 10.5 cycles of the sine wave in 10 cm of screen.

Finally, the sweep rate switch should be set to 10 ns/cm and a 100 mc signal applied to the input. The small trimmer on the sweep rate switch is then adjusted to provide 9.5 to 10.5 cycles for 110 cm of display.

For fast pulse work it may be desirable to calibrate with 500 mc at 2 ns/cm or with 1000 mc at INS/cm and fine tune the adjustment of the small trimmer for the part of the ramp in use.

All time ranges intermediate to the basic time ranges are derived by 1% resistors.

6.5 SWEEP START

This adjustment is located on the LCM board on the right side of the unit near the middle. The sweep start may be set to eliminate most of the non-linear beginning on the 1 microsecond per cm setting of the sweep rate switch. For this adjustment of the coarse sweep delay is turned full cw and the vernier delay turned full ccw. This adjustment should permit viewing the leading edge of a pulse on the 20ns/cm setting of the sweep rate switch with vernier and coarse delays fully cw. If not, a compromise setting should be made.

6.6 SWEEP LENGTH ADJUSTMENT R18

The sweep length adjustment pot is found on the UPS board. This is adjusted to provide 10cm ±2mm of sweep length on the display. This should be done with the unit triggering (trig. level cw) and the sweep source switch in Int.

6.7 STAIRCASE BALANCE

This adjustment is located on the UPS board. The adjustment is set so that the horizontal spot does not drift faster than approximately 1 cm/10 sec to the right when the trig. level is suddenly turned from cw to ccw. This adjustment should be made as the tube ages and if the unit is subjected to considerable temp ranges of operation, for the staircase is essentially a dc amplifier with a feedback holding capacitor and, therefore, subject to the long term drifts of a dc amplifier.

6.8 RISETIME SET (A & B CHANNELS)

This requires the use of a very fast (0.3ns) tunnel diode or a mercury pulser with a known wave shape.

1) The strobe amplitude pot on the top of the sampler board is turned to within 1/4 turn of max. strobe. This adjustment affects both A & B channels and all vertical adjustments to follow.

2) The response controls on the top of the sample boards are set so that a 10% to 90% risetime of 0.5ns or less with overshoot of 8% or less is seen when observing a pulser with risetime less than 0.1 ns and less than 2% overshoot. The response controls affect only their respective channels. Risetimes with other generators may be estimated by mean square.

6.9 SAMPLER BALANCE (A & B CHANNELS)

Zero volts is located on the 1120 frame display for both A & B channels. This may be done by shorting the inputs to the 1120 if a type 9001 service cable is used or by flipping the normal invert switch on the 701 and moving the dc offset unit the trace no longer shifts with zero input signal.

Next the volts/cm gain sw. is turned cw to 5mv/cm gain and the dc offset returned to twelve-o-clock. The sampler balance is then adjusted to return the display to zero volts.

6.10 AMP-BALANCE A & B CHANNEL

The volts/cm gain switch is turned ccw to 200mv/cm and the trace is returned to zero volts by moving the respective A or B channel amplifier balance located on the rear of the amplifier memory board on the left side of the unit. A channel is on top and B channel is on the bottom.

Once these adjustments are trimmed up, it should be possible to turn the volts/cm full cw to full ccw without the trace moving vertically more than 2 cm in either direction. In making this adjustment, be sure the front panel smoothing controls are off. If the trace is hashy at the 200 mv/cm setting, the dot response (amp gain) control near the front edge of the amp- mem. board may be advanced slightly cw, until a clean trace is obtained.

6.11 DOT RESPONSE (INTERNAL SMOOTHING) FOR A & B CHANNEL BOARD

The dot response is located toward the front of the amp-mem. board. There are two ways to set the dot response of the 701. In the first, a sine wave of approximately 5 cycle/10cm is displayed on the screen. The front panel samples/cm switch is alternately thrown from fine to coarse and the dot response is adjusted until the peak to peak amplitude does not change more than 5% under the two conditions with front panel smoothing off.

The second method involves putting a flat-topped pulse with approximately 10kc rep rate into the 701 and adjusting the trig. level and stability until a multiple synch is achieved where the display consists of 2 or three pulses of different heights starting from the same point in time. The dot response is adjusted until the pulses merge into a single amplitude and a baseline. The theory behind the second method is that samples are being taken on the baseline between pulses and on the tops of the pulses. If the amp loop gain is unity, the display should show only these points. If the gain is less than unity (oversmoothed) the trace will show intermediate levels. Similarly if the gain is greater than unity (under-smoothed) there will be an opposite polarity pulse on the trace.

After the dot response is set, the amp balance will probably have to be slightly readjusted and the risetime should be rechecked.

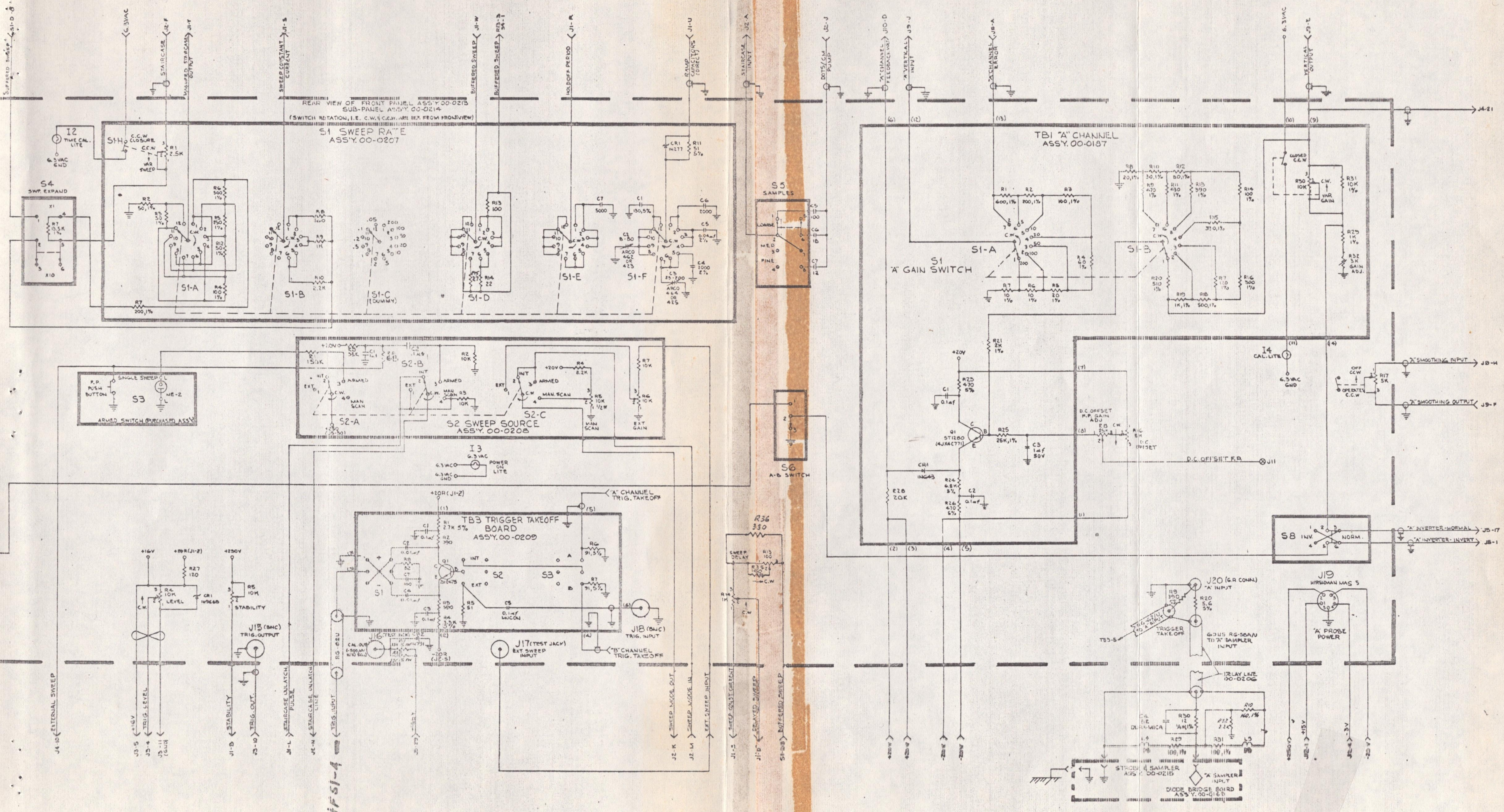
6.12 VERTICAL AMP CALIBRATION (use amp calib (067-508)

These adjustments are located just to the side of the respective volts/cm switches on the side of 701. The front panel -500 mv calibrate signal may be connected to the respective A & B channel inputs, one at a time, by clip lead and the vertical amplitude calibrate pots adjusted to give the proper deflection (5 cm on 100 mv/cm range).

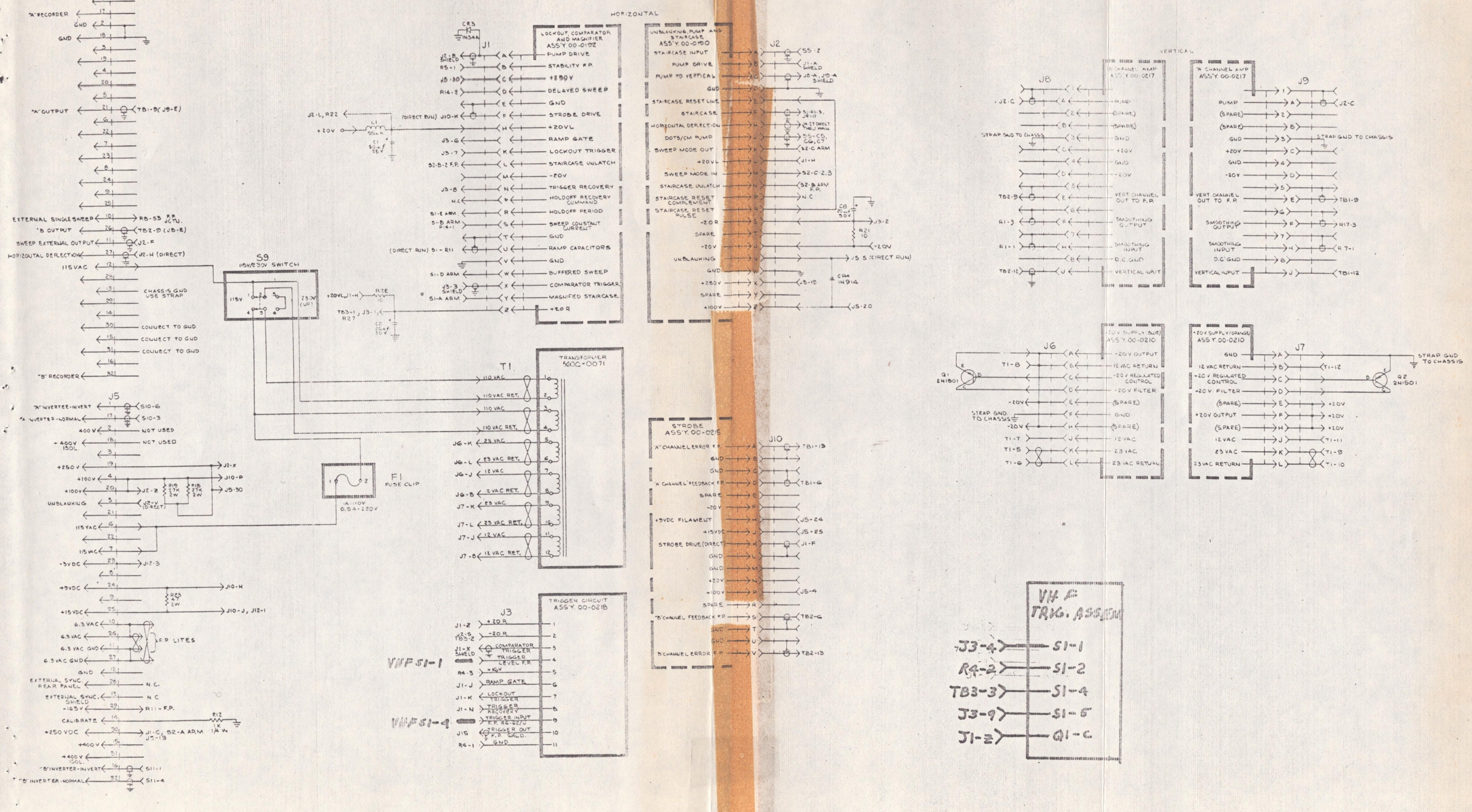
6.13 DC OFFSET GAIN POT.

This adjustment is located almost directly behind the dc offset output voltage jack. The dc offset front panel pot. is varied to produce a deflection of 10 cm at 100mv/cm volts/cm switch setting. The dc offset gain pot is then varied so that a voltage difference of 10 v ±10% is obtained at the dc offset output jack for the 10 cm deflection. The dc offset voltage should be monitored with a VTVM or high impedance voltmeter.

PLUG-IN SCHEMATIC

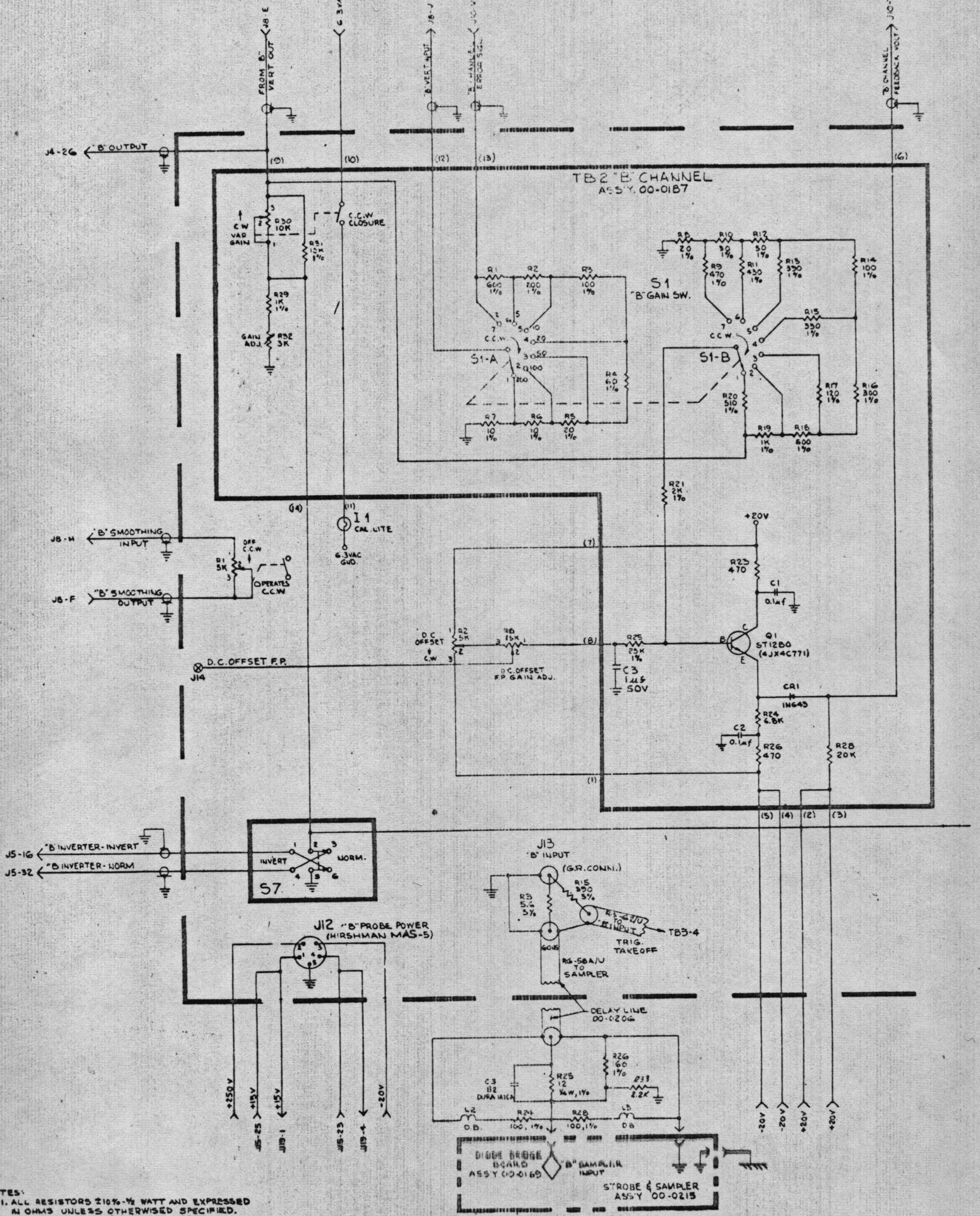


Drawing No. 977 010 000



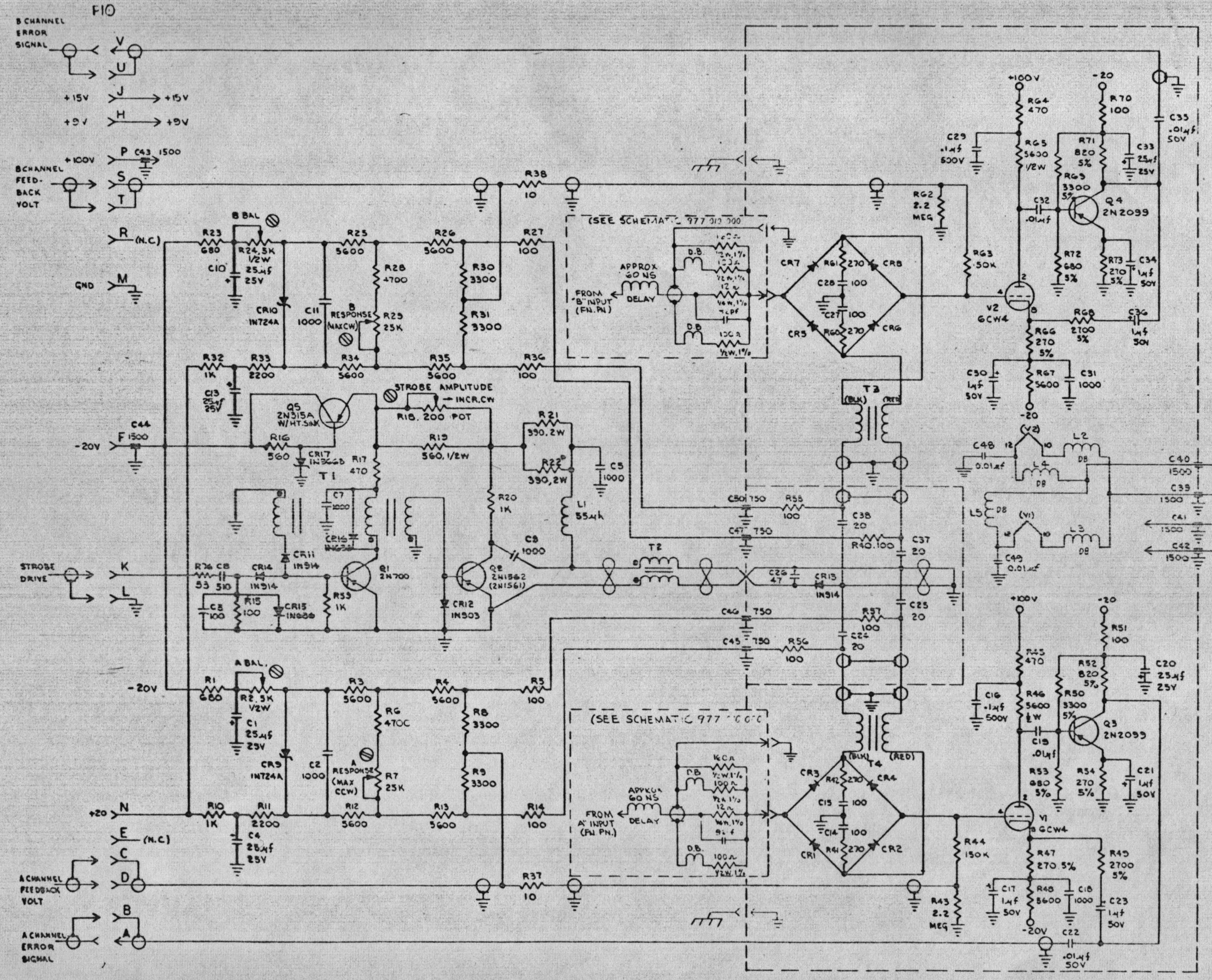
PLUG-IN WIRING DIAGRAM

Drawing No. 877 010 000



NOTES:
1. ALL RESISTORS ±10%-½ WATT AND EXPRESSED IN OHMS UNLESS OTHERWISED SPECIFIED.
2. ALL CAPACITORS ±20% AND EXPRESSED IN MICROMICROFARADS (pf) UNLESS OTHERWISE SPECIFIED.
3. LAST COMPONENT NUMBERS USED:
C8, CR3, F1, I4, J20, L5, Q2, R36, S9, TB3, T4
4. LEGEND:
FRONT PANEL ASS'Y.
PERMANENTLY MOUNTED SUB-ASS'Y.
REMOVEABLE OR REPLACEABLE SUB-ASS'Y

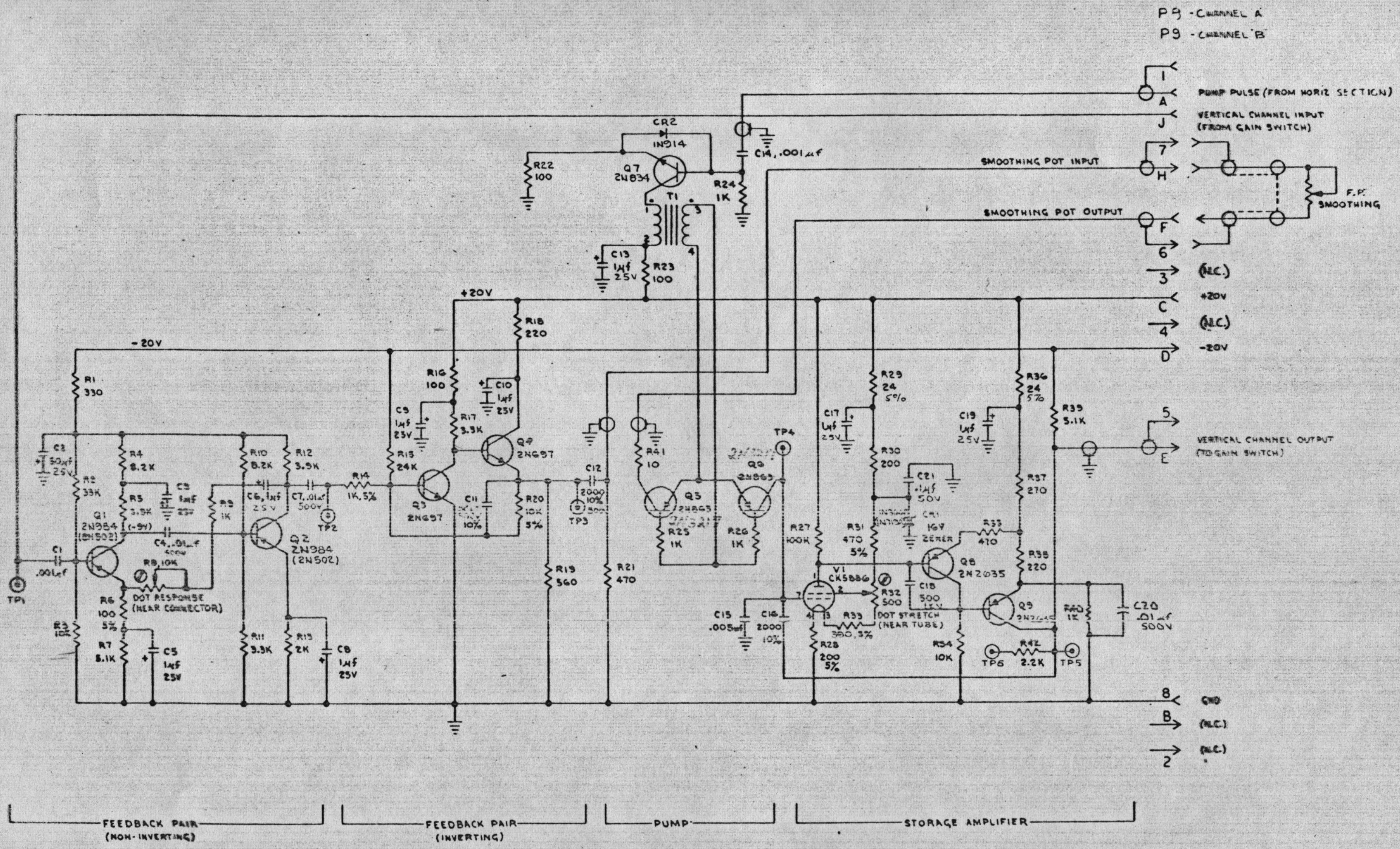
F10



NOTE:
1. ALL RESISTORS ±10% - 1/4 WATT AND EXPRESSED IN OHMS UNLESS OTHERWISE SPECIFIED
2. ALL CAPACITORS ±20% AND EXPRESSED IN MICRO-MICROFARADS (PF) UNLESS OTHERWISE SPECIFIED
3. LAST COMPONENT NUMBERS USED: C50, CR17, L5, Q5, R76, T4, V2
4. COMP. NO'S. NOT USED: R74; R75; R55, R39, C6, C12

SAMPLE STROBE ASSEMBLY 00-215

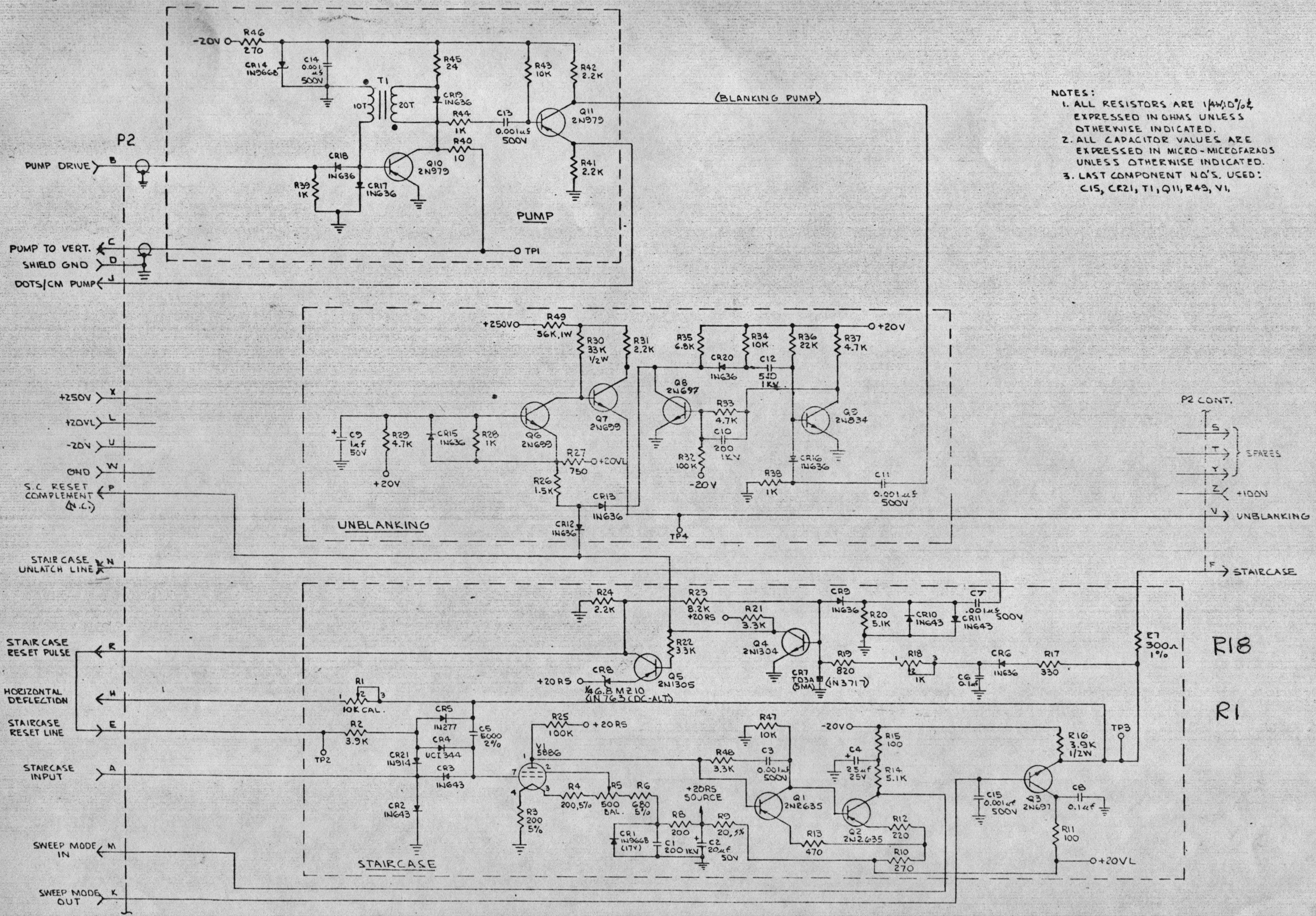
Drawing No. 907 015 000



NOTE:
1. ALL RESISTORS ±10% ½ WATT AND EXPRESSED IN OHMS UNLESS OTHERWISE INDICATED
2. ALL CAPACITORS ±20% AND EXPRESSED IN MICRO-MICROFARADS (pf) UNLESS OTHERWISE INDICATED
3. LAST COMPONENT NUMBERS USED: C21, CR2, Q9, R42, TP6, V1
4. NUMBER PINS DENOTE GROUND PLANE SIDE OF BOARD STARTING AT BOTTOM; LETTERS ARE ON OTHER SIDE OF BOARD WITH A OPPOSITE 1, ETC.
5. ARROWS INDICATE SIGNAL FLOW.

AMPLIFIER MEMORY ASSEMBLY 00-0217

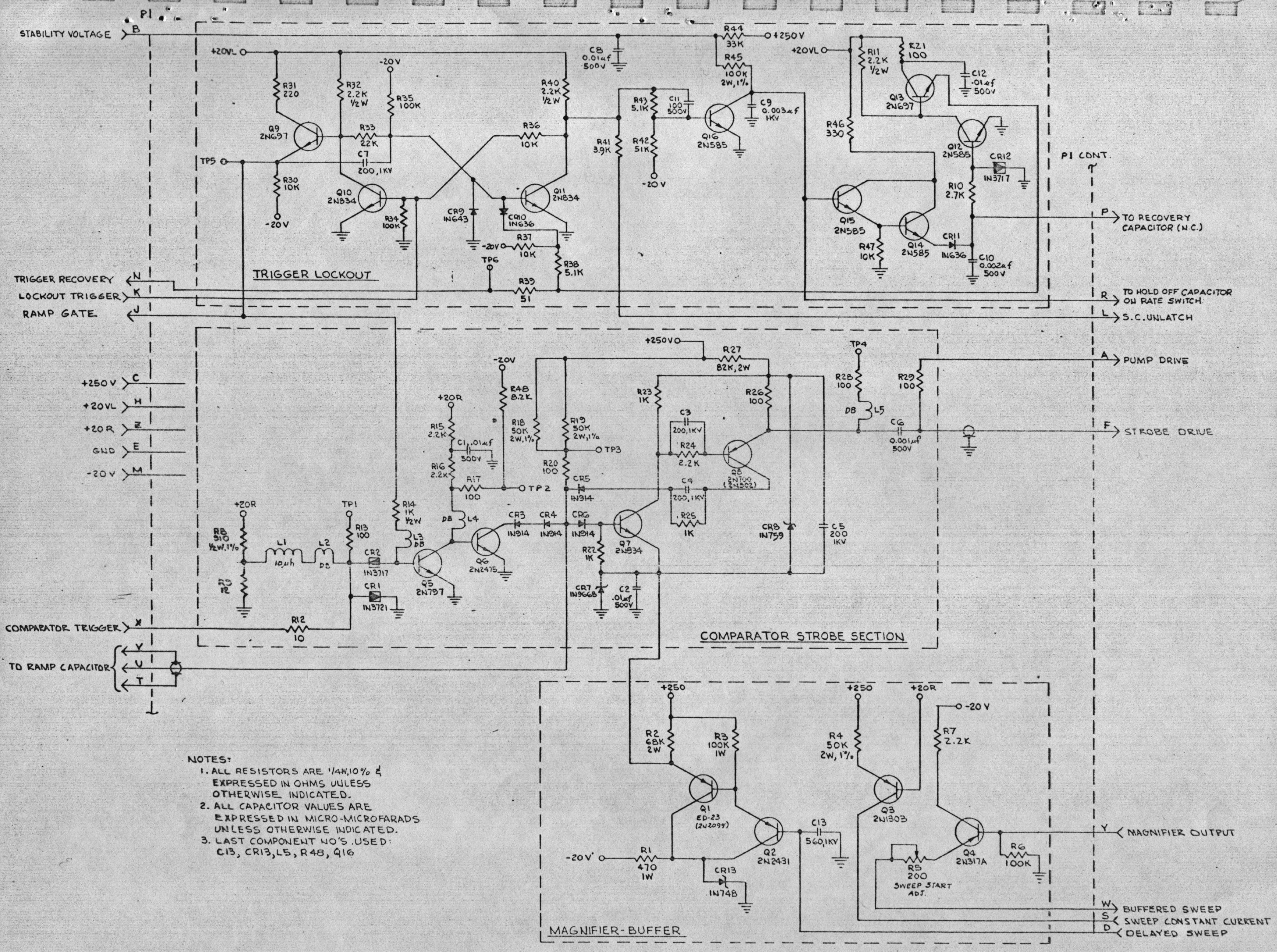
Drawing No. 907 011 000



NOTES:

1. ALL RESISTORS ARE 1/4W, 10% & EXPRESSED IN OHMS UNLESS OTHERWISE INDICATED.
2. ALL CAPACITOR VALUES ARE EXPRESSED IN MICRO-MICROFARADS UNLESS OTHERWISE INDICATED.
3. LAST COMPONENT NO'S. USED: C15, CR21, T1, Q11, R49, V1.

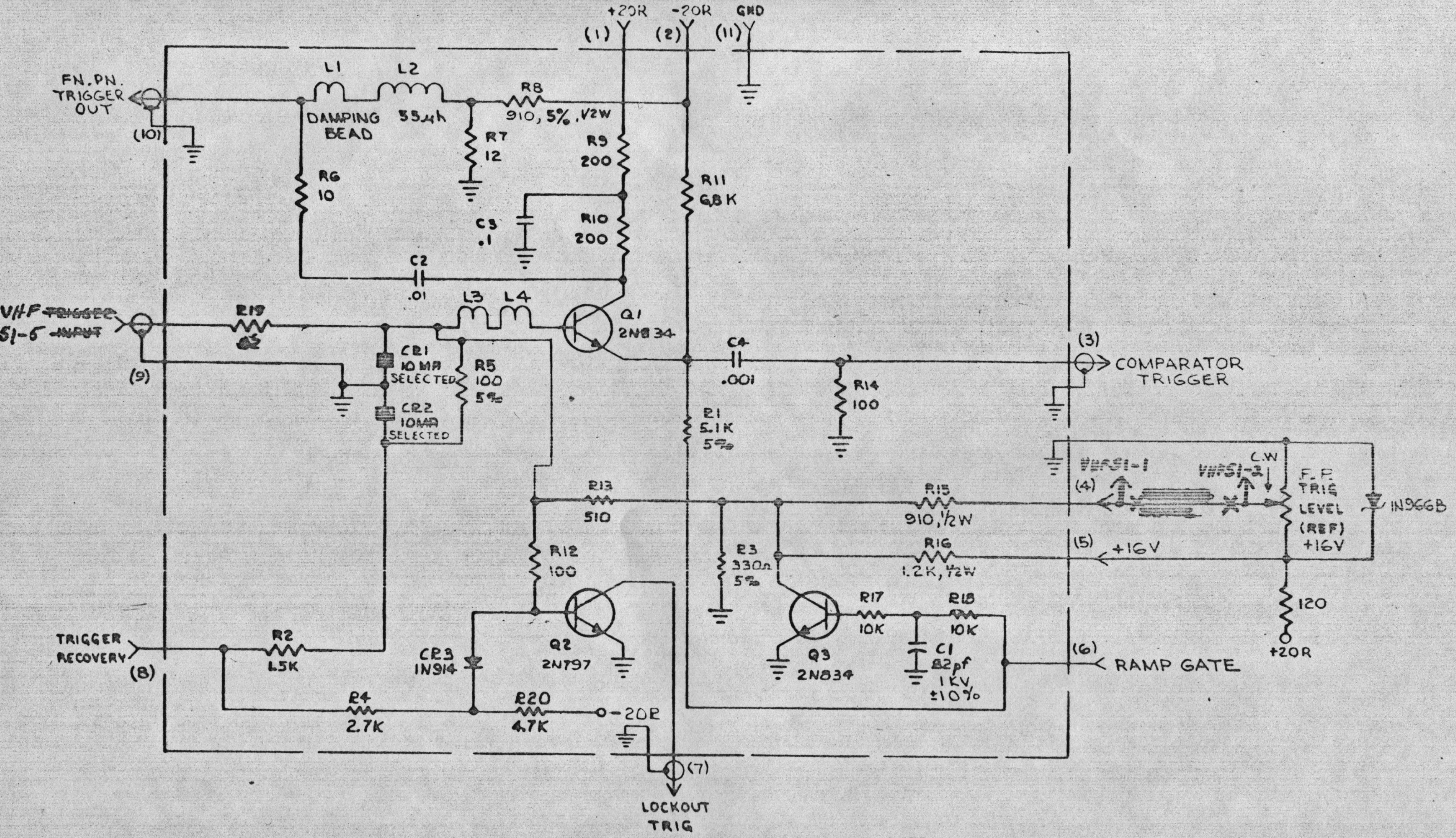
UNBLANKING, PUMP, STAIRCASE ASSEMBLY 00-0190 Drawing No. 907 013 001



NOTES:

1. ALL RESISTORS ARE 1/4W, 10% & EXPRESSED IN OHMS UNLESS OTHERWISE INDICATED.
2. ALL CAPACITOR VALUES ARE EXPRESSED IN MICRO-MICROFARADS UNLESS OTHERWISE INDICATED.
3. LAST COMPONENT NO'S. USED: C13, CR13, L5, R48, Q16

LOCKOUT, COMPARATOR MAGNIFIER ASSEMBLY 00-0192 Drawing No. 907 013 000

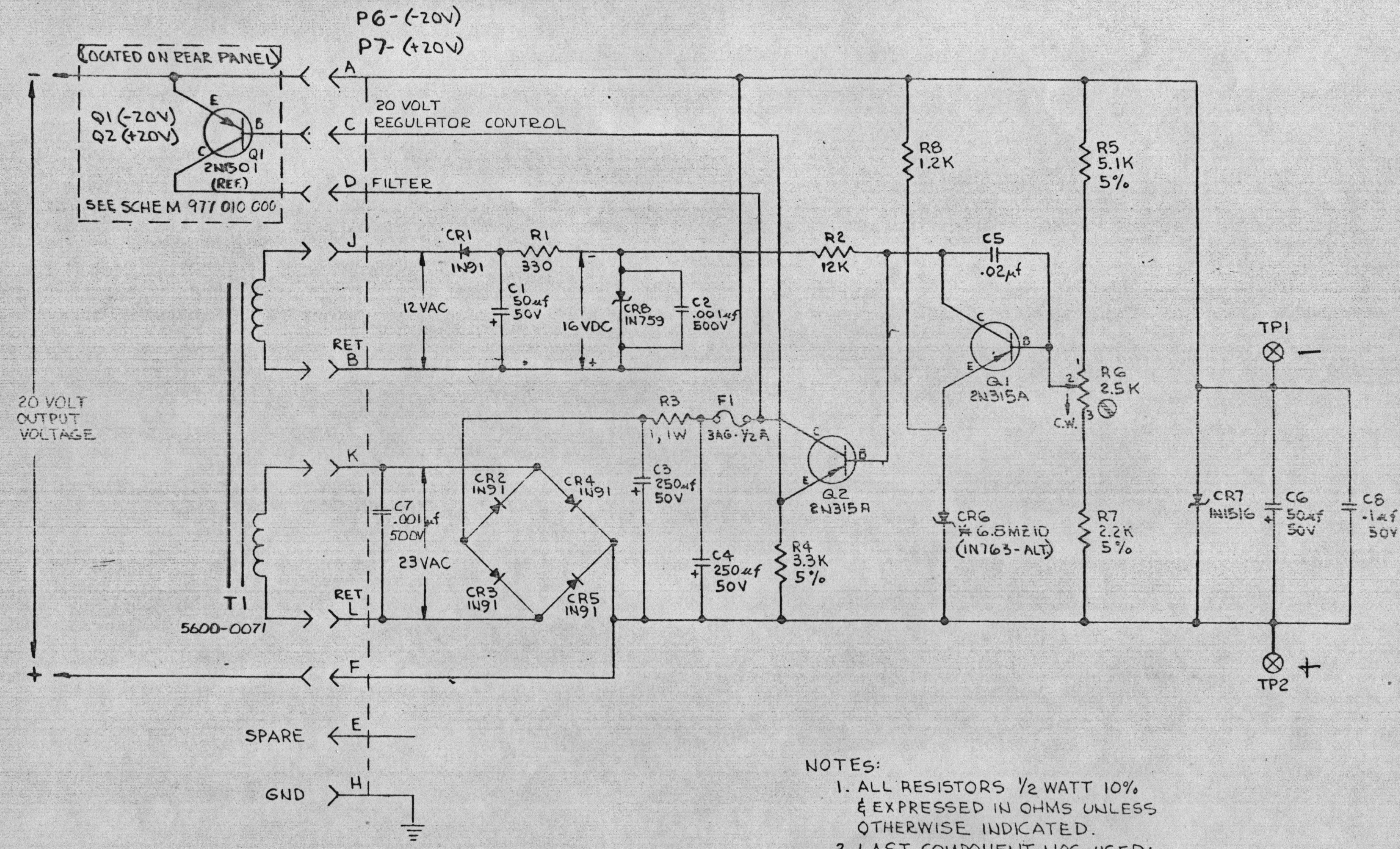


NOTES:

1. ALL RESISTORS ±10%-1/4W AND EXPRESSED IN OHMS UNLESS OTHERWISE INDICATED
2. ALL CAPACITORS ±20% AND EXPRESSED IN MICROFARADS UNLESS OTHERWISE INDICATED
3. LAST COMPONENT NUMBERS USED: R20, CR3, C4, L4, Q3

TRIGGER CIRCUIT BOARD ASSEMBLY 00-0218

Drawing No. 907 013 002



NOTES:

1. ALL RESISTORS 1/2 WATT 10% & EXPRESSED IN OHMS UNLESS OTHERWISE INDICATED.
2. LAST COMPONENT NOS. USED: C8, CR8, R8, Q2, F1

±20 VOLT POWER SUPPLY ASSEMBLY 00-0210

Drawing No. 907 016 000